THE TELEGRAPHIC JOURNAL AND

Electrical Review.

VOL. XI.—No. 249.

ASSOCIATION FRANÇAISE POUR L'AVANCEMENT DES SCIENCES.

(From our own Correspondent.)

ELEVENTH SESSION.

AUGUST 24TH TO 31ST, HELD AT LA ROCHELLE.

General Opening Sitting.

THE eleventh meeting of the "Association Française pour l'Avancement des Sciences" was opened on August 24th, 1882, at half-past two o'clock p.m., under the presidency of M. Janssen, a member of the institute.

M. Janssen thanked La Rochelle for its sympathetic reception and called attention to the gratitude which it owes to one of its members, M. Brunet, a wealthy merchant of the French Antilles, lately deceased, who left a considerable fortune to the association, a fortune of which it will make the best use in the interests of the progress of science.

According to custom, M. Janssen, who has devoted all his time and all his knowledge to the study of physical astronomy, took for the subject of his speech: "The Condition of Physical Astronomy." He showed how this science, purely descriptive at its commencement, soon developed into celestial mechanics and tends now to become, with the aid of lenses, of spectrum analysis, and of photography, a physical science. He showed what advantages can be derived from the new photographic processes, which, owing to their exquisite sensibility, enable the sun to be photographed in one hundred thousandth part of a second, and predicted that before long the gelatine plate would become the veritable retina of the *savant*.

After the remarkable speech of M. Janssen, of which we can only indicate the principal points in a review devoted specially to the progress of electricity, M. S. Dor, Mayor of La Rochelle, welcomed the members of the association, and pointed out the numerous subjects of study which could be found in the department of La Charente-Inférieure.

M. Emile Trélat, Professor at the Conservatoire des Arts et Métiers, general secretary of the association, then alluded to the history of La Rochelle; he touched upon the homage due to deceased members, the honours accorded to a large number of the members of the association, and described the salient features of the tenth session, held at Algiers in the spring of the year 1881.

M. G. Masson, treasurer, then gave a report of the increasing prosperity of the financial condition of the association, which numbers at present more than 4,000 members. After this speech the meeting concluded, and the members met in their respective sections to proceed to the nomination of offices, and to fix the order of the section sittings.

SECTION SITTINGS.

The association is divided into four groups; the first devoted to mathematical science, the second to physical and chemical science, the third to natural science, and the fourth to economic science. These groups are themselves sub-divided into sections to the number of fifteen. We will only give account here of the labours of the fifth section—Physics—which holds its sittings in the physical laboratory of the Lycée de La Rochelle.

PHYSICAL SECTION.

SITTING OF THE 24TH OF AUGUST.

President—M. Lallemand, doyen de la Faculté des Sciences de Poitiers.

Secretary—M. Leblond, professor of the torpedo school at Boyardville.

The members of this section, very few in number, at the first sitting separated, fixing the order of procedure, which it is useless to give here, since we shall devote an analysis, more or less detailed, to each of the electrical subjects treated of in each sitting.

SITTING OF THE 25TH OF AUGUST.

NEW ELECTRO-DYNAMIC BALANCE.

(For figure see next page.)

By M. DEBRUN, Professor at the Lycée de Pau.

The inventor sought to construct an instrument at once easily worked, sensitive, and exact. The apparatus is composed of a pair of fixed bobbins and a pair of movable bobbins, placed at both ends of a horizontal beam. The current to be measured traverses these four bobbins, arranged in circuit in such a manner that the two fixed bobbins repel the movable bobbins placed upon the beam. To protect the system from the action of terrestrial magnetism the beam is placed perpendicularly to the plane of the magnetic meridian. The beam supports two scale-pans, intended to hold the weights, which give equilibrium to the system. The method consists of balancing the dynamic action of the current by weights, until the beam recovers its equilibrium, and the spirals of the bobbins are at the same relative distance asunder.

To avoid the use of weights, which is inconvenient, M. Debrun combined a hydraulic *compensator*, which replaces them. Under one of the scale-pans is fixed a platinum cylinder, dipping half-way into water.

By altering the height of the liquid the pressure is altered. Knowing the diameter of the platinum wire, and the variation of the level of the liquid, one easily deduces the value of the pressure. M. Debrun increases the sensitiveness of the apparatus by making use of a large cylindrical vase, in communication with a tube and a narrow graduated gauge. Equilibrium is restored by forcing the water backwards or forwards by the aid of an india-rubber bulb, worked by a screw and fixed to the end of it; thus readings are more easily and more exactly taken upon a graduated scale, occupying the length of the gauge. For accurate experiments, M. Debrun brings the balance always to the same position by providing the extremity of the needle of the balance with a net formed of spider's web, and by making use of a micrometer microscope. It is with an apparatus of this kind, divided for the purpose, that M. Debrun has examined the electrical discharges produced by surfaces of mercury vibrating in liquid conductors.

For intense currents, such as those employed for the electric light, M. Debrun replaces the hydrostatic pressure by a spiral spring, which is stretched more or less by means of a graduated screw.

RESEARCHES UPON THE PHOTOMETRIC COMPARISON OF VARIOUSLY COLOURED SOURCES.

Paper by MM. MACÉ DE LÉPINAY and N. NICATI, read by M. MARCEL BRILLOUIN.

This question, apparently foreign to the subject which we are treating, is nevertheless directly attached to it, and is especially interesting to electricians who are in search of a simple, and above all, exact photometric process.

Two quantities of light may be considered equal when they illuminate the same colourless object (black upon a white ground, such as printed characters) placed always at the same distance from the same observer, and make him perceive the details of it with the same clearness, that is to say, when both quantities of light present the same clearness of outline.

We can, besides, consider two quantities of light as equal when they illuminate two colourless surfaces (white) and these surfaces appear equally illuminated; for example, in the Rumford photometer, when they give two shadows of the same intensity.

Unfortunately, it is difficult to appreciate the equality of clearness of two neighbouring surfaces differently coloured—for example, one blue and the other yellow. It is necessary in such a case to limit considerably the illuminated surfaces, as the smaller a surface is the less can the eye estimate its colouring.

The two methods above, based, one upon clearness of outline, the other upon the equality of illumination of two neighbouring surfaces,

are evidently equivalent when luminous sources of the same colour are being tested. For variously coloured lights, the experiments of M. Siemens and those of MM. Macé de Lepinay and Nicati prove that they are inapplicable.

Two quantities of light capable of giving two shadows of the same clearness, will not make equally distinct, black printed characters upon a white ground.

MM. Macé de Lepinay and Nicati have, therefore, undertaken some comparative experiments, and have established numerical relations which have led them to conclusions particularly interesting to electricians. We will reproduce them here.

It is quite evident that the principal object of public and private illumination is not to produce upon the eye a more or less intense sensation of light, but rather to enable us to distinguish what is round about us. Consequently, with equal illuminating power, there is evidently every advantage in the employment of a yellow illuminating source—intense gas jets or electric incandescent lamps—in preference to the employment of a source rich in blue rays, as is the electric arc.

This conclusion results from the fact that experiments made by both methods lead to results that correspond for all radiations *less* refrangible than greenish yellow, but that completely differ for radiations *more* refrangible.

Also, in order to characterise the practical value of a source of light, it is not sufficient to give its value in Carcels, a value deduced from the comparison of the shadows produced by these two sources, but there will be every advantage in determining at the same time the illuminating power of the source by a method deduced from clearness of outline. In this manner two numbers would be obtained which in some cases might be widely different, according to the nature of the source employed.

SITTING OF THE 26TH AUGUST, 1882.

LIGHT BICHROMATE OF POTASH BATTERY.

Result of the preliminary experiments performed by the aid of a dynamo-electric motor actuating an aerial screw.)

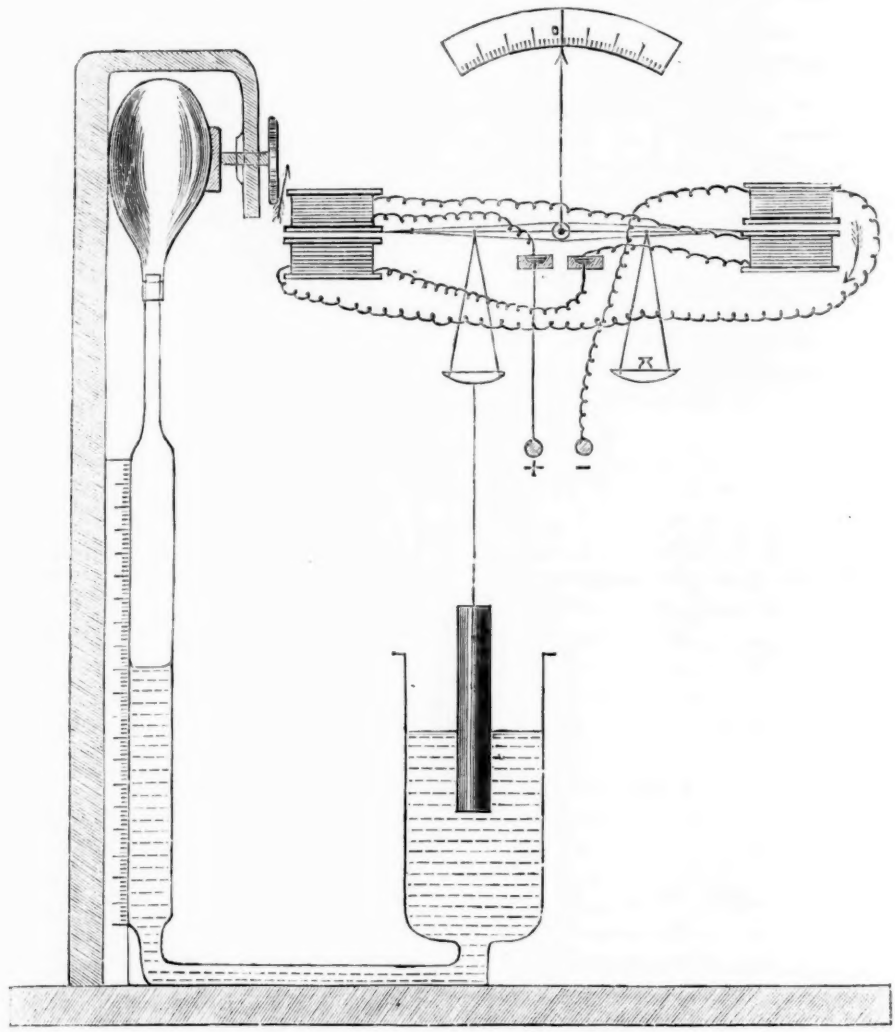
By M. GASTON TISSANDIER.

The writer proposed in his researches to realise the experiment made by M. Giffard in 1852 with a steam motor, making use of an aerial screw actuated by an electric motor. Its employment presents two advantages—absence of fire and constancy of weight. After having made experiments on a small scale with accumulators and bichromate of potash batteries on the model of M. Trouvé, and calculated that the bichromate batteries present greater constancy than is commonly supposed, M. Tissandier conceived the idea of the model which we shall describe, giving the results obtained from it.

Each element is composed of a parallelopipedical trough of ebonite, containing 10 plates of zinc alternated with 11 carbon plates. The weight of each element is expressed thus:—

	Grammes.
Zincs	1,200
Carbons	900
Ebonite vessel	860
Liquid (about four litres)	4,800
Accessories	200
Total	7,960

Or *eight* kilogrammes, in round numbers.



ELECTRO-DYNAMIC BALANCE.—M. DEBRUN.

The solution is composed (by weight) thus:—

	Parts.
Water	100
Bichromate of potash	16
Sulphuric acid	37

With the addition of a little bisulphate of mercury to maintain the amalgamation of the zincs. The great concentration of the solution diminishes the internal resistance of the element, increases its discharge per unit of time, and reduces the weight of water, which is a dead weight, to its minimum.

The constants of the element are:—

$$E = 2 \text{ volts.}$$
$$r = 0{\cdot}01 \text{ ohm.}$$

A battery of 18 elements in tension weighs 140 kilogrammes. It can supply upon an external circuit of 0·54 ohm resistance a current of 50 ampères for about an hour and a half, and a useful electric force of 135 kilogrammètres per second, from which could be derived 100 kilogrammètres of effective work (1¼ horse-power) for at least 90 minutes.

We will pass over the description of the screw and will consider the motor.

The motor is a continuous current dynamo-electric machine,

on the Siemens system, constructed and adapted specially for this purpose at the Siemens establishment at Paris, directed by M. Boistel.

All its parts, except the induced part, are of cast-steel, but they have been reduced to a minimum of weight and dimensions, for the machine, constructed to furnish 100 kilogrammètres with a current of 50 ampères, making 1,200 revolutions, only weighs 55 kilogrammes.

The battery and the machine, therefore, weigh no more than 200 kilogrammes; an elongated balloon of 1,000 cubic metres, 27 metres long and 9 metres diameter at the centre, is sufficient to support them. With a machine giving 100 kilogrammètres and a screw of 2·85 m. diameter, making 100 revolutions per second, M. Tissandier expects to obtain an average speed of 4 metres per second, which will allow him to deviate sensibly from the line of the wind, and even to direct himself in any direction in calm weather.

ON THE METHODS OF COMPARING THE CO-EFFICIENTS OF INDUCTION; CAUSES OF ERRORS, AND MEANS OF PREVENTING THEM.

By M. MARCEL BRILLOUIN.

The nature of this communication, of an order at once theoretical and experimental, does not admit of a succinct analysis, and could find no place here except with developments, which would lead us out of the course which we have traced for ourselves.

REGISTERING CAPILLARY ELECTROMETER.

By M. E. DEBRUN.

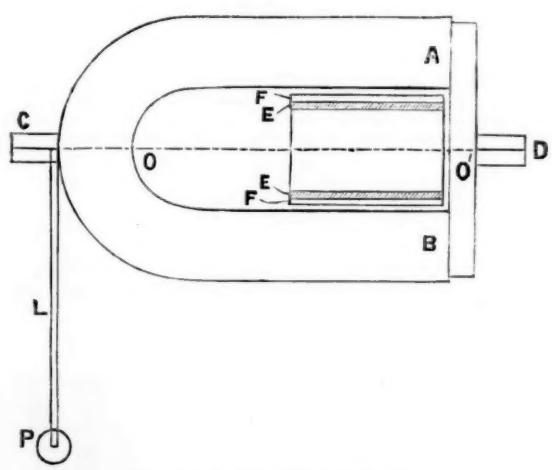
In certain investigations which demand an almost continuous observation of the difference of potential between two given points, it is very fatiguing to observe and record the variations of height of the column of mercury of the electrometer.

M. Debrun has combined, with the object of suppressing this fatigue, and of obtaining continuous and more precise results, a recording system, which is ingenious, but rather complicated. It would be impossible to make the mechanism understood without the assistance of a figure.

ELECTRO-MAGNETIC DETERMINATION OF THE MECHANICAL EQUIVALENT OF HEAT.

By M. MARCEL DEPREZ.

The experiments hitherto made to determine the mechanical equivalent of heat have given numbers which vary between 420 and 432. The errors arise chiefly from the imperfect process which serves to determine the labour expended. The method proposed by M. Marcel Deprez depends in principle upon a measurement of the effects of induction in the Foucault disc. To understand this method, it is necessary, in the first place, to remember the magnetic speed-indicator of M. Marcel Deprez. This apparatus is composed of



SPEED-INDICATOR.—MARCEL DEPREZ.

A, B. Horse-shoe magnet.
C, D. Knife edges.
E. Iron tube. F. Copper tube.
The two tubes turn concentrically round the axle O, O'.
L. Lever supporting the weight P.

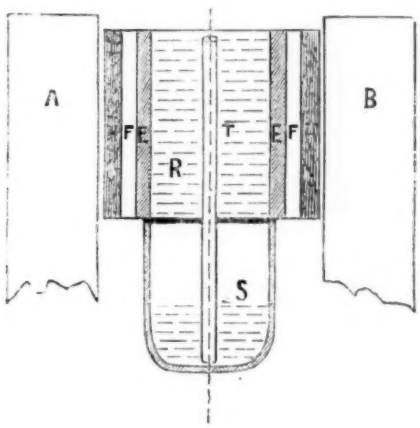
a horizontal horse-shoe magnet, bearing two knife edges upon its axis. Between the poles of this magnet is an iron tube, surrounded by a copper tube, to which a rapid rotary motion is imparted. The effects of induction tend to attract the magnet in the direction of the rotary motion, and it is necessary, in order to maintain equilibrium, to counterbalance this action by the aid of a counterpoise,* suspended at the extremity of a horizontal lever, perpendicular to the common axis of the magnet, and the revolving copper and iron tube.

Knowing the speed of rotation and the couple which equalises the inductive action, it is very easy to deduce therefrom the inductive energy absorbed by the system, energy which is transformed entirely into heat.

To obtain a constant speed, the copper and iron tube is set in motion by means of an electro-motor provided with a centrifugal interrupter, invented by M. Marcel Deprez. We can thus, and this is the preferable means, utilise the tendency to displacement of the magnet, under the influence of feeble variations of speed, to break or close the circuit of the electric motor which actuates the apparatus. The speed varies then only to a very small degree. The speed-indicator is therefore transformed into a Foucault disc, with a constant speed and of a peculiar form, in which the quantity of inductive energy, transformed into heat, is measured very exactly by means of the speed of rotation, and of the couple which equalises the magnet. It is important to observe that this method eliminates all passive resistances, only taking account of the inductive energy transformed into heat in the copper and iron tube. It remains now to measure the quantity of heat given out in the system in rotation.

To this end M. Marcel Deprez applies the principle of the sulphurous acid calorimeter of M. d'Arsonval. The apparatus designed for measurement comprises a movable magnet and a fixed copper and iron tube, that is to say, an arrangement the reverse of that for the speed-indicator. The interior of the fixed tube, closed at both extremities, is filled with sulphurous acid in communication by a small tube with an external reservoir. The evaporation of the sulphurous acid and its condensation in the external tube are effected by the most slight elevation of temperature. The volume of acid condensed in a given time indicates the number of calories furnished by the apparatus. Condensation occurring at the temperature of the surrounding air, there is no correction to make in this respect. In order that the feeble elevation of temperature of the tube of copper and iron may not produce any radiation and any loss of heat, this tube is enveloped in swan's down, which opposes radiation.

The tube being fixed and the magnet movable, the tube tends to be attracted by the magnet. The torsion couple is equalised by a platinum wire, the effect of which is measured, applying the laws of elasticity.



APPARATUS FOR MEASURING THE MECHANICAL EQUIVALENT OF HEAT.—MARCEL DEPREZ.

A, B. Ends of the revolving magnet.
E. Tube of iron. F. Tube of copper.
H. Envelope of swan's down.
R. Interior of tube enclosing sulphurous acid.
T. Tube of communication.
S. Sulphurous acid condensing chamber.

We have thus, on one hand, the exact measurement of inductive energy, and on the other hand the measurement of the heat liberated by this inductive energy. He deduces from it directly the value of the mechanical equivalent of heat, writing that the inductive energy in a given time, when the *régime* is established, is equal to the heat evolved deducted from the quantity of sulphurous acid condensed during the same time, multiplied by the mechanical equivalent of heat, the only unknown quantity in the problem. The apparatus is constructed with great accuracy, and gives the hope of determining the mechanical equivalent of heat as near as 1-1000 owing to the ingenious method of which M. Marcel Deprez has just presented the principle to the association.

* In the speed-indicator properly so called, the magnet, which has been properly tested, is inclined at a certain angle dependent on this speed, and it is this angle which permits of its determination.

SITTING OF THE 28TH AUGUST, 1882.

ELECTRICAL INCANDESCENT LAMPS ACTING IN THE OPEN AIR.

By M. EMILE REYNIER.

The process of incandescence in the open air, which I made known in 1878, is now abandoned. Various causes brought

this about; not to mention those of a technical order. I recognise that my old lamps have a rather low photometric effect; that certain of their parts are delicate, and call for attentions sometimes incompatible with the requirements of practice.

FIG. 1.

But these defects, connected with one system of lamp, and to the dispositions which have been given to it, are not inherent to the process of incandescence in the open air itself. I was therefore able to seek, with the same view, new systems, giving, like the old one, a white and fixed light, and in which the defects recognised in the old lamps will be eliminated or decreased. It is the results of these new researches which I wish to explain clearly.

I shall only illustrate by figures the principle of my old system (fig. 1) and its most usual form (fig. 2), to bring immediately to the fore the description of the unpublished details.

Second System.

With a given electric conductor, one can considerably increase its resistance by cutting it transversely in various places. The increase

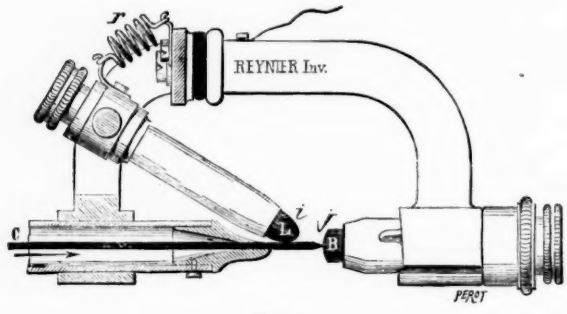


FIG. 2.

of resistance is more considerable in proportion as the sections are more numerous and smaller.

Fig. 3 shows a conductor of graphite composed of a certain number of superposed layers, moderately pressed together between two contacts.

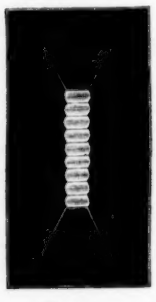


FIG. 3.

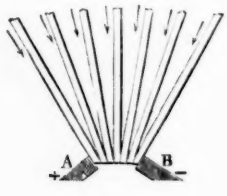


FIG. 4.

Such a conductor, mounted in a transparent, hollow, and completely closed receptacle, would constitute a good electric lamp; but its construction gives rise to difficulties which have not been overcome.

In air the combustion of the incandescent carbon necessitates the renewal of the material of the luminous matter. This is how the difficulty may be surmounted.

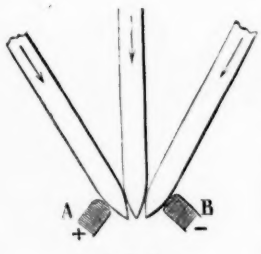


FIG. 5.

The dissected conductor is composed of the converging extremities of small rods of carbon, which come together between the two contacts, A and B (fig. 4), each rod is traversed, transversely and at its extremity only, by the electric current. With n carbons, one obtains $n + 1$ contacts. The renewal of the carbon as consumed is brought about by the continual progression of the carbons, which coincide, like the *voussoirs* of an arch, of which the contact pieces will be the piers.

The arrangement indicated in fig. 4 is only realisable with very thin carbons in the transverse direction; carbons of round or square section take a wolf's tooth form (fig. 5), which is unfavourable to the luminous effect of the apparatus, for the points relatively cold which stand out from the dissected conductor are the seat of a very important superfluous emission of heat.

FIG. 6.

We have overcome this difficulty in the arrangement, fig. 6. The dissected conductor describes a broken line, and the current, traversing the end of each rod obliquely, leaves no point out of circuit. Fig. 7 represents an electric lamp constructed upon this principle. The carbons, guided between two pumice-stone plates, are respectively propelled towards the opening of the lamp by unequal weights, sliding in grooves made in a brass triangle. The insulated pieces, A and B, serve as stops and as terminal contacts.

This lamp acts well, but we must wait, to judge of it, until it is provided with carbons of a very

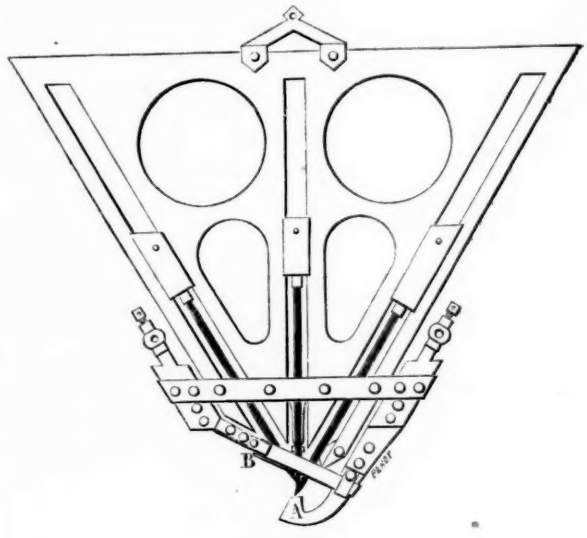


FIG. 7.

flattened section, which will allow of multiplication and of approximating the contacts, to simplify the lamp and diminish its size.

Provisionally, I prefer the following recent invention, which is more simple, less voluminous, and acting with any carbons whatever.

Third System.

I utilise here the thin form which we notice in the two preceding systems.

There are two rods of carbon made thinner at one end (fig 8); they are placed in the same plane, almost parallel to each other, and are approximated until they touch; their point of contact, x, will be

FIG. 8.

FIG. 9.

FIG. 10.

situated above the points, towards the base of the coning. The points being free, one can make them rest upon two contacts, A and B (fig. 9), and thus obtain an incandescent system in which the electric current

traverses successively, in the opposite direction, the two pointed ends, passing from one to the other by their lateral mutual contact.

To maintain the parts in this condition, notwithstanding the combustion of the points, it is necessary continuously to impel the carbons, in a longitudinal direction, and to give to the supporting contacts a suitable obliquity (fig. 10); the rods ought also to be guided in their common plane. Under these conditions, the pointed form is maintained; the carbons continue to impinge upon their respective contacts, and to touch each other at a certain distance above the points. Fig. 11 represents one practical form given to the apparatus. The carbons, A and B, are respectively impelled by weights, P and Q, sliding upon two metallic guides, C and D. The oblique contacts, E, F, are two sheets of copper, fixed upon bronze arcs, G, H. Two pairs of insulated clamps, I and J, connect the two halves of the lamp; the first pair is of wood, the second is of slate, and forms a slot, which guides the two carbons in their common plane.

The weights, P and Q, are insulated from the carbons which they impel, by ivory caps, *r* and *s*.

The electric current, entering by the terminal, K, follows the brass guide, C, the bend, G, the contact, E, goes up the pointed extremity of the carbon, A, passes over the contact, *x*, descends by the carbon end, B, and follows the contact, F, the bend, H, and the guide, D, to the terminal, L.

The two extreme contacts make little shadow; the middle contact causes no loss of heat or light, and usefully increases the total resistance of the lamp.

This combination of two very approximate incandescent points, and of three neighbouring contacts, procures a concentration of heat favourable to the photometric effect of the apparatus.

The experiments in progress will give, on this point, figures which will confirm the favourable impression produced by the first trials.

The apparatus is simple, easily manipulated, and of certain action; its narrow and symmetrical form allows of using it everywhere.

As to the necessity of renewing the carbons daily, it has been necessary, up to this day, to submit to it in all systems capable of giving *white* light with a good photometric effect.

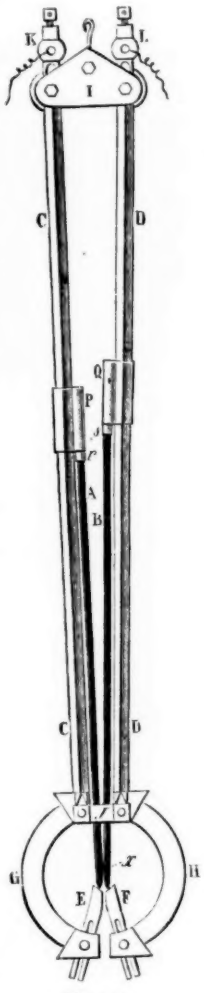


FIG. 11.

The most grave defect of my incandescent lamps is their too feeble resistance, which necessitates the employment of intense currents, the transmission of which is costly.

From this point of view, the third system, is superior to the first, but inferior to the second.

A DIFFERENTIAL ELECTRIC THERMOSCOPE.

By W. F. NOSWORTHY.

IT has of late frequently been pointed out to students and others that little real progress can be made in any branch of science from the cursory reading of a book; that by experiment alone can such subjects be successfully grappled with.

This is undoubtedly true; but it must be remembered that by far the greater portion of such persons are unable to attend lectures, join societies, or otherwise avail themselves of the facilities offered to those who have the good fortune to reside in London or other large city where these institutions exist, while the excessive cost of scientific apparatus, even of the most elementary nature (frequently exceeding many times the intrinsic value of the articles), forbids their procuring the necessary instruments wherewith to experiment at home.

This latter fact is undeniably a great obstacle to the progress of science, therefore whatever steps are taken tending to reduce the price of scientific apparatus generally will, I venture to say, be welcomed by all, and prove a material aid to science by increasing the number of workers in the field.

To persons engaged in the study of radiant heat, or even those who have occasionally to measure small differences of temperature, the possession of a thermopile is of paramount importance. The cost of this instrument is about £4 4s.

The object of the present communication is to call the attention of those interested to a simple arrangement which may with advantage replace the thermopile, and be constructed by any one at a cost not exceeding five shillings.

It has long been known that the electrical resistance of a wire varies with every change of temperature, the resistance increasing with a rise and diminishing with a fall of temperature. This fact forms the principle upon which the instrument about to be described is based.

Four coils of fine, silk-covered copper wire are joined up with a delicate galvanometer and a couple of Daniell's cells as a Wheatstone's bridge (fig. 1). If the resistances of the

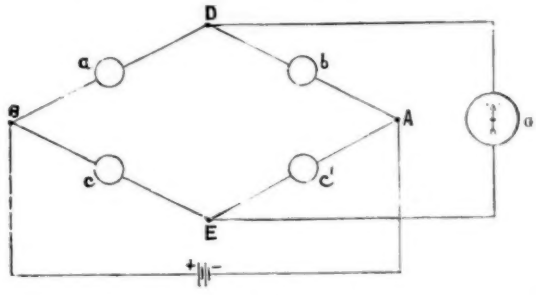


FIG. 1.

coils, *a*, *b*, C, C′, are equal and at the same temperature, the points, D and E, will be at the same potential; therefore no current will flow through the galvanometer, G.

Suppose, now, the temperature of one of the coils, C, for example, be raised, the resistance of that coil will be increased and the potential of the point, F, thereby reduced relatively

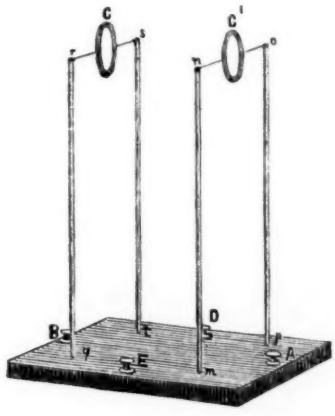


FIG. 2.

to that of D, consequently a current will flow through G in the direction from D to E, causing a deflection, say, to the left. On the other hand, if it be the temperature of C′ that is increased the potential of E will be raised above that of D, and the direction of the current through G reversed, the deflection in this case being to the right. If however the temperature of both C and C′ be increased or reduced by exactly equal amounts, no change will take place in the potential at E, and there will be no deflection of the galvanometer.

From what has now been stated fig. 2 will be readily understood.

The two coils, *a*, *b* (fig. 1), are embedded in the base of the instrument, while the coils, C, C′, are supported, as shown, by the four glass tubes, *m n*, *o p*, *q r*, *s t*, through which the connecting wires from the respective coils pass to the terminals on the base. The battery may be connected to the terminals, B, A, and the galvanometer to D, E, or *vice versâ*. Arranged thus, the instrument forms a differential thermoscope of great sensibility, and can be used in every case where the thermopile has hitherto been employed.

In the instrument represented by the drawing the four coils are composed of No. 40 silk-covered copper wire and

have a resistance of 20 B.A. units each. The coils, C, C′, are further coated with lampblack. The galvanometer used in connection therewith is an astatic mirror, of which a section having a resistance of 125 ohms has been employed.

It will be seen that the relation between the resistance of the galvanometer and coils is not such as to give the maximum sensibility to the arrangement, nevertheless the comparisons made between this instrument and a thermopile of forty-eight pairs of antimony-bismuth plates, having a resistance of 1·4 units, and joined up with an astatic reflecting galvanometer of 1·5 units resistance, specially constructed for use with the pile, are extremely satisfactory, for when a source of heat is placed equidistant from the two the galvanometer in connection with the thermoscope invariably gives the highest deflection, and is also the first to sink to zero when the source of heat is removed.

For those who have not the means of measuring the resistance, the coils may be made of equal lengths of wire. As, however, owing probably to mechanical defects in manufacture, two equal lengths of the same wire seldom have exactly the same resistance, it will be necessary to finally adjust the coils by adding or cutting off a small piece of the wire until the galvanometer shows no movement when the battery circuit is closed. Sufficient time should elapse between touching the coils and making this trial to allow the wire to assume the temperature of the atmosphere, otherwise the coil last touched will appear to have the greatest resistance.

Many improvements in the construction of the instrument will readily suggest themselves, the form shown in the figure has, however, answered all my requirements, indeed since its completion I have seldom used the thermopile.

CHASTER'S TELEPHONIC APPARATUS.

THIS arrangement, which is shown in general appearance by fig. 1, is the invention of Mr. J. E. Chaster. It is a very convenient and neat adaptation of an electro-magnetic telephone with a microphonic transmitter.

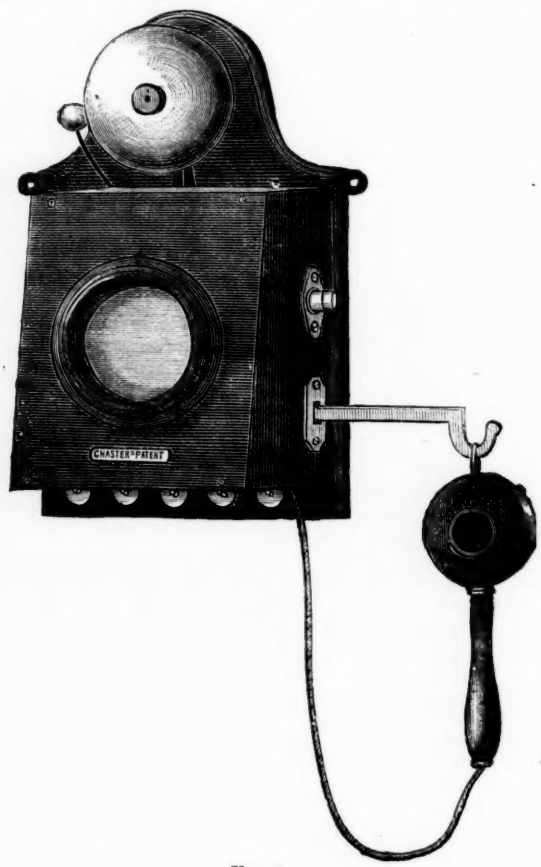


FIG. 1.

The receiver of this apparatus (the essential portion of which is shown in section by fig. 2) will be readily understood by those conversant with telephonic matters. The metal case in which the electro-magnetic coil is enclosed is of iron, and practically forms a prolongation of the lower pole of the electro-magnet. The edges of the ferrotype

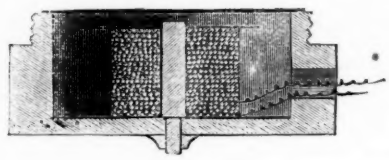


FIG. 2.

diaphragm rest on the edge of the metal box, and are secured by means of a screw cap. The magnetisation of the electro-magnet is effected by means of the line current, there being no induction-coil in the apparatus.

The microphonic transmitter, which is a feature in the apparatus, can be seen in fig. 3. It is formed of four vertical carbon pencils connected up in sets of two, the current passing down one set and up the other, as can be seen. The microphones are set on a thin board, which is hinged at the top, and which is kept pressed gently forward against its frame by means of a lead weight. The front surface of the board is opposite a round orifice (seen in fig. 1), into which the operator speaks. We may mention in conclusion that the four upright pieces of carbon-pencil belonging to the microphone transmitter are each wrapped round their middles with a band of sheet lead for the purpose of increasing their weight.

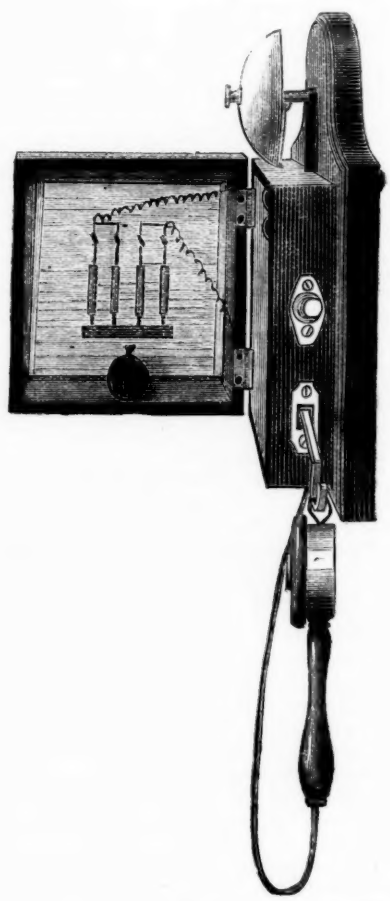


FIG. 3.

The apparatus is provided with the usual switch lever alarum bell, and push button.

REPORT OF ELECTRICAL TESTS OF THE "1881" AND "1882" ATLANTIC CABLES OF THE AMERICAN TELEGRAPH AND CABLE COMPANY.

Taken at Penzance on the 1st and 2nd July, 1882.

SIEMENS BROTHERS & CO.'s TELEGRAPH WORKS,
MESSRS. SIEMENS BROS. & Co., Charlton Pier, Woolwich, Kent.
12, Queen Anne's Gate, Westminster. *July 27th*, 1882.

DEAR SIRS,—In accordance with your instructions, I proceeded to Penzance for the purpose of testing the "1881" and "1882" cables of the American Telegraph and Cable Company, to which end every facility was afforded me by the Company's Superintendent there, Mr. Mockridge. On the evening of the 1st instant, I tested the "1881" and "1882" cables separately, and on the 2nd instant, took a series of tests of both cables together, their ends being joined at Canso. I enclose a detailed description of the methods employed, the observations recorded, and the results deduced therefrom. I was fortunate in finding the cables remarkably free from disturbance by earth currents during the whole time I tested, and the results obtained are therefore the more accordant, and, as you will gather from inspection of the results, highly satisfactory, and evidencing both cables to be in perfect electrical condition.

I am, dear Sirs, yours faithfully,
FRANK JACOB, M.S.T.E., M.P.S. Lond., &c.

METHODS OF TESTING.

CONDUCTOR RESISTANCE.

This was determined by "reproduced deflection" as follows:—

The cable, with its distant end to earth, is connected through a suitably shunted galvanometer and battery with reversing key to earth, and a series of deflections (the battery being reversed between each reading) are taken as rapidly as possible and recorded; a resistance box is then substituted in place of the cable, and varied until the same deflections are reproduced; the resistances thus obtained are equal to the apparent resistances offered by the cable to either current. The harmonic mean of the results, with positive and negative current to line respectively, gives the true resistance of the conductor. The advantage gained by this over the usual "bridge" method is, that reversals can be taken far more rapidly, and the variation caused by earth currents, as well as being continuously under observation, be most easily eliminated; and if an "inferred zero" be used, by having the spot, when no current is passing through the galvanometer coils, considerably off the scale, the results can be determined to the same degree of accuracy as in the method referred to above.

ELECTRO-STATIC CAPACITY.

This was determined by the "Balance" method, as described by Sir W. Thomson in his Report of Testing the Direct United States Cable Company's cable, on the 16th and 17th December, 1875.

DIELECTRIC RESISTANCE.

This, as the earth currents were found to be remarkably steady, was measured in the ordinary way by the "deflection" method.

A battery of 40 Daniell's elements in series was used for all the tests.

Length of Cables from Sennen (Cornwall) to Dover Bay (Nova Scotia):

"1881" cable .. .. .. 2517·76 nautical miles.
"1882" cable .. .. .. 2562·70 ,, ,,

At the Cornwall end there is a quadruple underground cable laid to Penzance, the resistance of each core being 19·5 Siemens units, and electro-static capacity 3·1 microfarads. On the Nova-Scotian side four underground cables connect to Canso, having each a resistance of 15·5 Siemens units, and a capacity of 2·5 microfarads. The dielectric resistance of these may be neglected, in comparison with that of the submarine cables, without introducing any perceptible error.

Earth is obtained for each cable by one of the underground cables, which is connected at the landing place by well-soldered and massive joints to the sheathing wires of each shore-end cable respectively.

ELECTRICAL TESTS OF THE "1881" CABLE.

From 8.15 to 8.25 p.m., on July 1st, this cable was earthed and then insulated until 9.15 p.m. at Canso.

CONDUCTOR RESISTANCE.

Negative current to line 8,570 S.U. } harmonic mean =
Positive ,, ,, 7,650 S.U. } 8,084 Siemens units.

Subtracting 70 S.U. for the resistance of the underground cables at each side, we obtain 8,014 Siemens units as the resistance of the submarine cable, or a mean, per nautical mile, of 3·184 Siemens units.

ELECTRO-STATIC CAPACITY.

Negative current to line 904·9 mfds. } mean = 892·6
Positive ,, ,, 880·3 ,, } microfarads.

Subtracting 5·6 microfarads for that of the underground cables, we obtain 887 microfarads as the capacity for the submarine cable, or a mean of 0·352 microfarad per nautical mile.

DIELECTRIC RESISTANCE.

The "constant" of the galvanometer or the resistance which with infinite resistance in the shunt would give a deflection of one division, was 19,700 millions Siemens units, and the deflections through the cable were taken with a shunt having one-ninth of the galvanometer's resistance.

The results are exhibited in tabular form.

Column I. gives the time of electrification;
,, II. ,, the mean deflection observed each minute;
,, III. ,, the resistance calculated from "II.";
,, IV. ,, these resistances reduced for electrification to the value for the first minute's electrification, so as to obtain the mean first minute result from the ten minutes' test.

POSITIVE CURRENT TO LINE.

I. Minutes.	II. Deflection.	III. Millions Siemens units.	IV. Millions Siemens units.	
1	320	6·16	6·2	
2	230	8·56	7·1	
3	300	6·57	5·1	
4	230	8·56	6·3	Mean of results reduced to electrification after first minute = 8·3 millions Siemens units, or 20,900 millions Siemens units per nautical mile.
5	100	19·70	[14·2]*	
6	180	10·95	7·6	
7	150	13·14	8·9	
8	120	16·42	10·9	
9	120	16·42	10·6	
10	100	19·70	11·9	

NEGATIVE CURRENT TO LINE.

I. Minutes.	II. Deflection.	III. Millions Siemens units.	IV. Millions Siemens units.	
1	410	4·80	4·8	
2	330	5·97	4·9	
3	200	9·85	7·6	
4	100	19·70	14·6	Mean of results reduced to electrification after first minute = 7·4 millions Siemens units, or 18,640 millions Siemens units per nautical mile.
5	50	39·40	[28·3]*	
6	180	10·95	7·6	
7	180	10·95	7·4	
8	200	9·85	6·5	
9	200	9·85	6·3	
10	170	11·59	7·3	

The cable was earthed for ten minutes between the tests with the two currents.

Mean of results with both currents to line, reduced to electrification after first minute:

7·85 millions Siemens units for the whole cable, or 19,770 millions Siemens units per nautical mile.

ELECTRICAL TESTS OF THE "1882" CABLE.

Earthed at Canso 9.15 to 9.25 p.m., and insulated till 10.15 p.m.

CONDUCTOR RESISTANCE.

Negative current to line 8,334 S.U. } Mean:
Positive ,, ,, 8,334 ,, } 8,334 Siemens units.

No difference between the results with each current, thus evidencing the smallness of the earth currents. Subtracting 70 Siemens units for the resistance of the underground cables, this gives 8,264 Siemens units for the resistance of the submarine cable, or a mean, per nautical mile, of 3·225 Siemens units.

ELECTRO-STATIC CAPACITY.

The same with both currents to line, viz., 930·6 microfarads. Subtracting 5·6 microfarads for the underground cables, the submarine cable has a capacity of 925 microfarads, or a mean of 0·361 microfarad per nautical mile.

DIELECTRIC RESISTANCE.—POSITIVE CURRENT TO LINE.

I. Minutes.	II. Deflection.	III. Millions Siemens units.	IV. Millions Siemens units.	
1	320	6·16	6·2	
2	270	7·30	6·1	
3	260	7·58	5·9	
4	250	7·88	5·8	Mean of results reduced to electrification after first minute = 7·0 millions Siemens units, or 17,940 millions Siemens units per nautical mile.
5	220	8·95	6·4	
6	210	9·39	6·5	
7	170	11·59	7·8	
8	160	12·31	8·1	
9	160	12·31	7·9	
10	140	14·07	8·9	

* The figures in brackets are excluded, being due to a variation in earth currents.

NEGATIVE CURRENT TO LINE.

I. Minutes.	II. Deflection.	III. Millions Siemens units.	IV. Millions Siemens units.	
1	320	6·16	6·1	
2	170	11·59	9·6	
3	170	11·59	9·0	
4	220	8·95	6·6	Mean of results reduced to electrification after first minute = 7·8 millions Siemens units, or 20,000 millions Siemens units per nautical mile.
5	170	11·59	8·3	
6	150	13·14	9·1	
7	180	10·95	7·4	
8	100	19·70	[13·0]*	
9	220	8·95	5·8	
10	150	13·14	8·3	

The cable was earthed for ten minutes between each series.

Mean of results with both currents to line, reduced to electrification after first minute,

= 7·4 Siemens units for the whole cable, or 18,970 millions Siemens units per nautical mile.

ELECTRICAL TESTS OF THE "1881" AND "1882" CABLES JOINED.

July 2nd, 8.15 a.m., both cables were joined at Canso.

CONDUCTOR RESISTANCE.

Measured by the "bridge" method.

— 16,409 Siemens units
+ 16,284 Siemens units } mean = 16346·5 Siemens units.

Subtracting 70 Siemens units for the resistance of the underground cables at each end, gives:

16276·5 Siemens units for the sum of the resistance of the two cables, which agrees very closely with the sum of the resistances of the two cables taken separately the day before, viz., 16,278 Siemens units.

DIELECTRIC RESISTANCE.

The deflections were taken with a shunt having a resistance 1-99th of that of the galvanometer, and the "constant" was 19,600 millions Siemens units.

For these two series the ends of both cables were connected at Penzance, and thus the circuit was charged simultaneously from both ends.

NEGATIVE CURRENT TO LINE.

I. Minutes.	II. Deflection.	III. Millions Siemens units.	IV. Millions Siemens units.	
1	70	2·80	2·80	
2	58	3·38	2·82	
3	32	6·12	4·74	
4	55	3·56	2·64	Mean reduced to electrification after first minute = 3·945 millions Siemens units, or 20,040 millions Siemens units per nautical mile.
5	20	9·80	7·05	
6	60	3·26	2·27	
7	25	7·84	5·30	
8	35	5·60	3·71	
9	40	4·90	3·16	
10	25	7·84	4·96	

Cable earthed for ten minutes, then

POSITIVE CURRENT TO LINE.

I. Minutes.	II. Deflection.	III. Millions Siemens units.	IV. Millions Siemens units.	
1	90	2·18	2·18	
2	60	3·26	2·72	
3	47	4·17	3·23	
4	35	5·60	4·15	Mean reduced to electrification after first minute = 3·961 millions Siemens units, or 20,120 millions Siemens units per nautical mile.
5	35	5·60	4·03	
6	20	9·80	6·80	
7	40	4·90	3·31	
8	20	9·80	6·49	
9	40	4·90	3·16	
10	35	5·60	3·54	

The cable was again earthed for fifteen minutes, and then the following series taken by charging the end of the "1881" cable and leaving the end of the "1882" cable insulated free in air at Penzance. It will be noticed that the first three minutes' readings give higher deflections than in the former series; this is due to the length of cable now existing between the charging battery and the distant end, which is insulated, thus increasing the time required for the cable to arrive at a uniform tension throughout.

* The figures in brackets are excluded, being due to a variation in earth currents.

NEGATIVE CURRENT TO LINE.

I. Minutes.	II. Deflection.	III. Millions Siemens units.	IV. Millions Siemens units.	
1	190	1·03	1·03	
2	75	2·61	2·18	
3	50	3·92	3·04	
4	45	4·36	3·23	Mean of results reduced to electrification after first minute = 4·25 millions Siemens units, or 21,600 millions Siemens units per nautical mile.
5	30	6·53	4·70	
6	20	9·80	6·80	
7	20	9·80	6·62	
8	20	9·80	6·49	
9	30	6·53	4·21	
10	15	13·06	[8·26]*	

The cable was then earthed for ten minutes, and the following series taken, with the end of the "1882" cable charged, and the end of the "1881" cable insulated free in air at Penzance.

POSITIVE CURRENT TO LINE.

I. Minutes.	II. Deflection.	III. Millions Siemens units.	IV. Millions Siemens units.	
1	200	0·98	0·98	
2	75	2·61	2·18	
3	60	3·27	2·53	
4	30	6·53	4·84	Mean of results reduced to electrification after first minute = 3·95 millions Siemens units, or 20,070 millions Siemens units per nautical mile.
5	30	6·53	4·70	
6	10	19·60	[13·61]*	
7	30	6·53	4·41	
8	25	7·84	5·19	
9	30	6·53	4·21	
10	20	9·80	6·20	

The mean of the four series of tests of the two cables joined at Canso gives a result for the first minute's electrification of 4·026 millions Siemens units, or 20,450 millions Siemens units per nautical mile.

Appended is a summary of the tests of the two cables since completion of laying up to date, as well as of the results obtained from the sum of the tests of the separate coils composing each cable, which were taken at the works during the manufacture of the cable at the two fixed temperatures of 75° and 50° Fahrenheit.

SUMMARY OF RESULTS OF ELECTRICAL TESTS OF THE "1881" AND "1882" ATLANTIC CABLES.

	"1881" CABLE. Length = 2517·76 nautical miles.			"1882" CABLE. Length = 2562·7 nautical miles.		
	Mean of the tests taken from both terminal points during the time from 9th July, 1881 (completion of cable), to 25th July, 1882.	Calculated from the sum of the tests of the separate coils composing the cable, taken during manufacture.		Mean of the tests taken from both terminal points during the time from April 3rd, 1882 (completion of cable), to 25th July, 1882.	Calculated from the sum of the tests of the separate coils composing the cable, taken during manufacture.	
		At 75° F.	At 50° F.		At 75° F.	At 50° F.
Conductor resistance in Siemens units... ... Total	8036	8727	8281	8267	8993	8533
Conductor resistance mean per nautical mile	3·192	3·466	3·289	3·226	5·509	3·330
Electro-static capacity in microfarads ... Total	918	936·3	935·1	929·3	937·2	936·0
Electro-static capacity mean per nautical mile	0·3646	0·3720	0·3714	0·3626	0·3657	0·3651
Dielectric resistance in millions Siemens units after one minute's electrification ... ... Total	7·1	0·2025	1·600	6·5	0·1982	1·566
Dielectric resistance mean per nautical mile	17880	510	4030	16660	508	4014
$\Sigma \frac{1}{p \times t}$ = Co-efficient for reduction of total resistance to that per nautical mile at 75° F. and pressure of one atmosphere	92·9	2517·7	318·7	81·55	2562·7	324·3
Dielectric resistance thus reduced, in millions Siemens units	660	510	510	530	508	503

FRANK JACOB, *Chief Electrician.*

* The figures in brackets are excluded, being due to a variation in earth currents.

THE BRITISH ASSOCIATION.

[*Specially reported for the* ELECTRICAL REVIEW.]

ADDRESS TO THE MATHEMATICAL AND PHYSICAL SCIENCE SECTION.

BY LORD RAYLEIGH, M.A., F.R.S., F.R.A.S.

IN common with some of my predecessors in this chair, I recognise that probably the most useful form which a presidential address could take would be a summary of the progress of physics, or of some important branch of physics, during recent years. But the difficulties of such a task are considerable, and I do not feel myself equal to grappling with them. The few remarks which I have to offer are of a general—I fear it may be thought of a commonplace—character. All I can hope is that they may have the effect of leading us into a frame of mind suitable for the work that lies before us.

The diversity of the subjects which come under our notice in this section, as well as of the methods by which alone they can be adequately dealt with, although a sign of the importance of our work is a source of considerable difficulty in the conduct of it. From the almost inevitable specialisation of modern science, it has come about that much that is familiar to one member of our section is unintelligible to another, and that details whose importance is obvious to the one fail altogether to rouse any interest in the mind of the other. I must appeal to the authors of papers to bear this difficulty in mind, and to confine within moderate limits their discussion of points of less general interest.

Even within the limits of those departments whose foundation is evidently experimental, there is room, and indeed necessity, for great variety of treatment. One class of investigators relies mainly upon reiterated appeals to experiment to resolve the questions which appear still to be open, while another prefers, with Thomas Young, to base its decisions as far as possible upon deductions from experiments already made by others. It is scarcely necessary to say that in the present state of science both methods are indispensable. Even where we may fairly suppose that the fundamental principles are well established, careful and often troublesome work is necessary to determine with accuracy the constants which enter into the expression of natural laws. In many cases the accuracy desirable, even from a practical point of view, is hard to attain. In many others, where the interest is mainly theoretical, we cannot afford to neglect the confirmations which our views may derive from the comparison of measurements made in different fields, and in face of different experimental difficulties. Examples of the inter-dependence of measurements apparently distinct will occur to every physicist. I may mention the absolute determinations of electrical resistance, and of the amounts of heat developed from electrical and mechanical work, any two of which involve also the third, and the relation of the velocity of sound to the mechanical and thermal properties of air.

Where a measurement is isolated, and not likely to lead to the solution of any open question, it is doubtless possible to spend upon it time and attention that might with advantage be otherwise bestowed. In such a case we may properly be satisfied for a time with work of a less severe and accurate character, knowing that with the progress of knowledge the way is sure to be smoothed both by a better appreciation of the difficulties involved and by the invention of improved experimental appliances. I hope I shall not be misunderstood as underrating the importance of great accuracy in its proper place if I express the opinion that the desire for it has sometimes had a prejudicial effect. In cases where a rough result would have sufficed for all immediate purposes, no measurement at all has been attempted, because the circumstances rendered it unlikely that a high standard of precision could be attained. Whether our aim be more or less ambitious, it is important to recognise the limitations to which our methods are necessarily subject, and as far as possible to estimate the extent to which our results are uncertain. The comparison of estimates of uncertainty made before and after the execution of a set of measurements may sometimes be humiliating, but it is always instructive.

Even when our results show no greater discrepancies than we were originally prepared for, it is well to err on the side of modesty in estimating their trustworthiness. The history of science teaches only too plainly the lesson that no single method is absolutely to be relied upon, that sources of error lurk where they are least expected, and that they may escape the notice of the most experienced and conscientious worker. It is only by the concurrence of evidence of various kinds and from various sources that practical certainty may at last be attained, and complete confidence justified. Perhaps I may be allowed to illustrate my meaning by reference to a subject which has engaged a good deal of my attention for the last two years —the absolute measurement of electrical resistance. The unit commonly employed in this country is founded upon experiments made about twenty years ago by a distinguished committee of this association, and was intended to represent an absolute resistance of 10^9 C.G.S.—*i.e.*, one ohm. The method employed by the committee at the recommendation of Sir W. Thomson (it had been originally proposed by Weber) consisted in observing the deflection from the magnetic meridian of a needle suspended at the centre of a coil of insulated wire, which formed a closed circuit, and was made to revolve with uniform and known speed about a vertical axis. From the speed and deflection in combination with the mean radius of the coil and the number of its turns, the absolute resistance of the coil, and thence of any other standard, can be determined.

About ten years later Kohlrausch attacked the problem by another method, which it would take too long to explain, and arrived at the result that the B.A. unit was equal to 1·02 ohms—about 2 per cent. too large. Rowland, in America, by a comparison between the steady battery current flowing in a primary coil with the transient current developed in a secondary coil when the primary current is reversed, found that the B.A. unit was ·991 ohms. Lorentz, using a different method again, found ·980, while H. Weber, from distinct experiments, arrived at the conclusion that the B.A. unit was correct. It will be seen that the results obtained by these highly competent observers range over about 4 per cent. Two new determinations have lately been made in the Cavendish laboratory at Cambridge, one by myself with the method of the revolving coil, and another by Mr. Glazebrook, who used a modification of the method followed by Rowland, with the result that the B.A. unit is ·986 ohms. I am now engaged upon a third determination, using a method which is a modification of that of Lorentz.

In another important part of the field of experimental science, where the subject-matter is ill understood, and the work is qualitative rather than quantitative, success depends more directly upon sagacity and genius. It must be admitted that much labour spent in this kind of work is ill-directed. Bulky records of crude and uninterpreted observations are not science, nor even in many cases the raw material out of which science will be constructed. The door of experiment stands always open; and when the question is ripe, and the man is found, he will nine times out of ten find it necessary to go through the work again. Observations made by the way, and under unfavourable conditions, may often give rise to valuable suggestions, but these must be tested by experiment, in which the conditions are simplified to the utmost, before they can lay claim to acceptance.

When an unexpected effect is observed, the question will arise whether or not an explanation can be found upon admitted principles. Sometimes the answer can be quickly given; but more often it will happen that an assertion of what *ought* to have been expected can only be made as the result of an elaborate discussion of the circumstances of the case, and this discussion must generally be mathematical in its spirit, if not in its form. In repeating, at the beginning of the century, the well-known experiment of the inaudibility of a bell rung in vacuo, Leslie made the interesting observation that the presence of hydrogen was inimical to the production of sound, so that not merely was the sound less in hydrogen than in air of equal pressure, but that the actual addition of hydrogen to rarefied air caused a diminution in the intensity of sound. How is this remarkable fact to be explained? Does it prove that, as Herschel was inclined to think, a mixture of gases of widely different densities differs in its acoustical properties from a single gas? These questions could scarcely be answered satisfactorily but by a mathematical investigation of the process by which vibrations are communicated from a vibrating solid body to the surrounding gas. Such an investigation, founded exclusively upon principles well established before the date of Leslie's observation, was undertaken years afterwards by Stokes, who proved that what Leslie observed was exactly what ought to have been expected. The addition of hydrogen to attenuated air increases the wave-length of vibrations of given pitch, and consequently the facility with which the gas can pass round the edge of the bell from the advancing to the retreating face, and thus escape those rarefactions and condensations which are essential to the formation of a complete sound wave. There remains no reason for supposing that the phenomenon depends upon any other elements than the density and pressure of the gaseous atmosphere, and a direct trial, *e.g.*, a comparison between air and a mixture of carbonic anhydride and hydrogen of like density, is almost superfluous.

Examples such as this, which might be multiplied *ad libitum*, show how difficult it often is for an experimenter rightly to interpret his results without the aid of mathematics. It is eminently desirable that the experimenter himself should be in a position to make the calculations, to which his work gives occasion, and from which in return he would often receive valuable hints for further experiment. I should like to see a course of mathematical instruction arranged with especial reference to physics, within which those whose bent was plainly towards experiment might, more or less completely, confine themselves. Probably a year spent judiciously on such a course would do more to qualify the student for actual work than two or three years of the usual mathematical curriculum. On the other side it must be remembered that the human mind is limited, and that few can carry the weight of a complete mathematical armament without some repression of their energies in other directions. With many of us difficulty of remembering, if not want of time for acquiring, would impose an early limit. Here, as elsewhere, the natural advantages of a division of labour will assert themselves. Innate dexterity and facility in contrivance, backed by unflinching perseverance, may often conduct to successful discovery or invention a man who has little taste for speculation; and on the other hand the mathematician, endowed with genius and insight, may find a sufficient field for his energies in interpreting and systematising the work of others.

The different habits of mind of the two schools of physicists sometimes lead them to the adoption of antagonistic views on doubtful and difficult questions. The tendency of the purely experimental school is to rely almost exclusively upon direct evidence, even when it is obviously imperfect, and to disregard arguments which they stigmatise as theoretical. The tendency of the mathematician is to overrate the solidity of his theoretical structures, and to forget the narrowness of the experimental foundation upon which many of them rest.

By direct observation, one of the most experienced and successful experimenters of the last generation convinced himself that light of definite refrangibility was capable of further analysis by absorption. It has happened to myself, in the course of measurements of the absorbing power of various media for the different rays of the spectrum, to come across appearances at first sight strongly confirmatory of Brewster's views, and I can therefore understand the persistency with which he retained his opinion. But the possibility of further analysis of light of definite refrangibility (except by polarisation) is almost irreconcilable with the wave theory, which on the strongest grounds had been already accepted by most of Brewster's

contemporaries; and in consequence his results, though urgently pressed, failed to convince the scientific world. Further experiment has fully justified this scepticism, and in the hands of Airy, Helmholtz, and others, has shown that the phenomena by which Brewster was misled can be explained by the unrecognised intrusion of diffused light. The anomalies disappear when sufficient precaution is taken that the refrangibility of the light observed shall really be definite.

On similar grounds undulationists early arrived at the conviction that physically light and invisible radiant heat are both vibrations of the same kind, differing merely in wave-length; but this view appears to have been accepted slowly, and almost reluctantly, by the experimental school.

When the facts which appear to conflict with theory are well-defined and lend themselves easily to experiment and repetition, there ought to be no great delay in arriving at a judgment. Either the theory is upset, or the observations, if not altogether faulty, are found susceptible of another interpretation. The difficulty is greatest when the necessary conditions are uncertain, and their fulfilment rare and uncontrollable. In many such cases an attitude of reserve, in expectation of further evidence, is the only wise one. Premature judgments err perhaps as much on one side as on the other. Certainly in the past many extraordinary observations have met with an excessive incredulity. I may instance the fire-balls which sometimes occur during violent thunderstorms. When the telephone was first invented, the early reports of its performances were discredited by many on quite insufficient grounds.

It would be interesting, but too difficult and delicate a task, to enumerate and examine the various important questions which remain still undecided from the opposition of direct and indirect evidence. Merely as illustrations I will mention one or two in which I happen to have been interested. It has been sought to remedy the inconvenience caused by excessive reverberation of sound in cathedrals and other large unfurnished buildings by stretching wires overhead from one wall to another. In some cases no difference has been perceived, but in others it is thought that advantage has been gained. From a theoretical point of view it is difficult to believe that the wires could be of service. It is known that the vibrations of a wire do not communicate themselves in any appreciable degree directly to the air, but require the intervention of a sounding-board, from which we may infer that vibrations in the air would not readily communicate themselves to stretched wires. It seems more likely that the advantage supposed to have been gained in a few cases is imaginary than that the wires should really have played the part attributed to them.

The other subject on which, though with diffidence, I should like to make a remark or two, is that of Prout's law, according to which the atomic weights of the elements, or at any rate of many of them, stand in simple relation to that of hydrogen. Some chemists have reprobated strongly the importation of *à priori* views into the consideration of the question, and maintain that the only numbers worthy of recognition are the immediate results of experiment. Others, more impressed by the argument that the close approximations to simple numbers cannot be merely fortuitous, and more alive to the inevitable imperfections of our measurements, consider that the experimental evidence against the simple numbers is of a very slender character, balanced, if not outweighed, by the *à priori* argument in favour of simplicity. The subject is eminently one for further experiment; and as it is now engaging the attention of chemists, we may look forward to the settlement of the question by the present generation. The time has perhaps come when a redetermination of the densities of the principal gases may be desirable—an undertaking for which I have made some preparations.

If there is any truth in the views that I have been endeavouring to impress, our meetings in this section are amply justified. If the progress of science demands the comparison of evidence drawn from different sources, and fully appreciated only by minds of different order, what may we not gain from the opportunities here given for public discussion, and, perhaps more valuable still, private interchange of opinion? Let us endeavour, one and all, to turn them to the best account.

THE EDISON SYSTEM OF ELECTRIC DISTRIBUTION.

[Paper by F. J. SPRAGUE, read at meeting of Section A of British Association, Friday, August 25th, 1882.]

I WISH to speak of Mr. Edison's system as it has appeared to me after a thorough investigation and study of the same, extending over several months and with great facilities at my command, and my conclusions are based not on Mr. Edison's claims, or those of his friends, but as the result of a candid investigation. Mr. Edison's ambition has been far reaching, and he designs to establish a system of distribution, not alone for lighting, but for almost every purpose to which the electric current can be put; and he recognises the all-important principle that all parts of such a system are mutually dependent; that thorough mathematical and engineering talent must be used; that no detail is so unimportant, no real objection so trivial, but that it requires patient consideration; that dynamos, meters, lamps, motors, conductors, districts laid out, capital invested, and energy wasted, must all be calculated with reference to each other; in short, that economy and reliability are the great ends to be attained. The result is that he comes now before the world, after three years of hard work and patient experimenting, feeling fully equipped and able to establish thoroughly reliable and extensive installations. I have stated some of the requirements of a system of general distribution, and will consider that of Mr. Edison in detail and as a whole. I shall not give a full description of all the parts, but intend rather to consider it from a practical and economic point of view.

DYNAMOS.

These generators, which have armatures wound or connected on a modification of the Hefner-Alteneck system, may be divided into three classes.

1. Those having wire-wound armatures, the coils being wound on a wooden cylinder wrapped with a soft iron wire. These armatures are driven by belting, and rotate between the faces of long vertical magnets at a speed of 800 to 1,200 revolutions per minute, according to the size of machine and the number of lamps. By using a large mass of metal a powerful magnet may be created, rendering necessary a less number of convolutions of wire, and consequently less heat and waste in the armature for a given electromotive force. By using long magnets the mean resultant of the convolutions of wire is brought much nearer the centre of the core than would be the case with the same weight of metal and a shorter length. On account of this a more active magnetic field is produced, one with a greater projective power, and less current may be used in the field coils. This can be exemplified in a striking manner by reforging the cores with the same amount of iron, but making them shorter and rewinding with the same amount of wire as now used. With the same speed of armature and the same number of convolutions the electromotive force of the machine will fall very appreciably; and this lower electromotive force can be obtained by using the large magnets with the faces at a much greater distance from the surface of the armature. The commutator is long; its life or time of running without repair is thus increased, and should a movable commutator be fitted, the trouble of taking care of a machine would be reduced to a minimum. There are four varieties, or classes, with capacities of 70, 150, 250, and 500 lamps, and the number of magnets depends on the size of the machine. Each pair of cores are in series. If two or more pairs are used, the pairs are thrown in parallel circuit.

The resistance of the field coils may be roughly expressed by $\frac{3{,}000}{L}$ where L is the maximum number of lamps. In the 70 lighter this resistance is 40·4 ohms cold, and 41·5 warm, and the field is in parallel circuit with the external circuit. The machine generates an electromotive force of about 110 volts and runs very quietly. Ordinarily 60 lamps would be the proper load if running for a long time, but 85 can be readily carried for a shorter period. The ordinary limit to the power of a machine is the heating of the armature, which depends upon the total volume of current flowing. The armature has a resistance of ·16 ohms cold and ·20 warm. With a difference of potential of 100 volts at the terminals, the field coils would require 10,650 foot-pounds of electrical energy expended per minute, or ·32 horse-power, *i.e.*, about a pound of coal per hour. The energy lost in the armature would be $c^2 \times 8{\cdot}848$, c being total current in ampères. With a circuit of seventy 140-ohm lamps, the external resistance, including the field coils, but not the conductors which are very low, would be two ohms, over 9·5 times the internal. My experience with the larger machines of this type does not warrant me in commenting on their performance, but from the knowledge of their construction, I should judge their efficiency to be about the same. 9 or 10 horse-power should be delivered to the pulley of the 70-light machine.

2. The second class comprises machines with magnets as in the first, which may be coupled in series, or in parallel circuit making their resistance about ¼, and enabling a given electromotive force to be obtained with a lower speed. The armature is built up of iron discs, and has a sheathing of copper bars, connected across the ends by copper discs. It is of very low resistance, in the ordinary size 1-10th of that of the 70-lighter. It is run at the same speed, develops a lower locomotive force, and is suitable for lamps of lower resistance. The following table is from a careful test of this machine by Mr. J. A. Howell, at Stephen's Institute. These tests were made—the first, by means of the voltameter; the second, by calorimeter; and the third, by the electromotive force and resistance method. By "efficiency" is meant the ratio of the total electrical energy developed to the power required to turn the armature in the magnetic field. By "commercial efficiency" is meant the ratio of energy appearing in the external circuit to the power required to drive the machine, including friction.

DATA.	1st Experiment.	2nd Experiment.	3rd Experiment.
Time of duration	·15	·16	—
Speed of dynamometer	400·5	394·	355·
Resistance of armature	·016	·016	·016
Total resistance of circuit	·773	·696	·658
E.M.F.	64·74	55·10	53·00
C.	83·75	79·17	80·55
Efficiency	·955	·967	·935
Commercial efficiency	·861	·901	·87
Foot-pounds of electrical energy in—			
1. Armature	4965·	5604·	5026·
2. Field coils	4647·	4216·	3347·
3. External circuit...	230268·	233940·	198301·
Percentage of same appearing in—			
1. Armature	2·07	2·30	2·43
2. Field coils	1·94	1·73	1·62
3. Both	4·01	4·03	4·05
4. External circuit...	95·99	95·97	95·95

These armatures are somewhat difficult of construction, but it seems to me their efficiency is so remarkable that the extra expense is warrantable, and I should like to see all the machines constructed on this rather than on the wire principle.

3. This class comprises machines with armatures on the same plan as the last, but are much larger, of lower resistance and of double the electromotive force. The field magnets are horizontal, have twelve cores, and their resistance is about 1-7th that of the 70 lighter. The armature is connected directly to the engine, which is a well proportioned, high speed, non-condensing engine, known as the Porter-Allen; only three of these dynamos are in Europe, one being in Paris and two at the central station at Holborn Viaduct. The normal capacity of No. 3 is 1,000 lights, but it can be readily run up to 1,200 or 1,300, and by coupling the field magnets so that their resistance is about 4-9ths of the Holborn machine, Mr. Edison recently ran 1,630 lamps at twenty candle-power, and I have been informed that No. 3, before leaving New York, was tested with 1,320 lamps for fifteen consecutive hours, I suppose at sixteen candles. From Howell's experiments, one lamp of 140·5 ohms resistance required for an illumination of sixteen candles a potential of 99 volts, and used 3,107·41 foot-pounds of energy per minute. The potential and resistance give a current of 0·7046 ampères, which is about the average of five lamps. 1,320 lamps would then require 930·072 ampères, and the external resistance would be ·1064 ohms, or twenty-eight times the internal. Call the resistance of leading wires ·01 ohm, a tenth of the lamp resistance, which will give a lamp circuit resistance of ·1164 ohm. The resistance of the field magnets is 6·73 cold. Allow 5 per cent. increase in these coils, and 10 per cent in the armature for heating, and consider the conductor resistance as between the lamps and machines. Thence we have a difference of potential at the brushes, and terminals of the field coils, of 108·05 volts and a field current of 15·29 ampères, giving a total current in the armature of 945·36 ampères, and an electromotive force of 111·67 volts. This gives an equivalent of 73,090 foot-pounds in the field coils, 387,200 in the leading wires, 163,690 in the armature, and 4,064,050 in the lamps, making a total of 4,688,030 foot-pounds of electrical energy per minute. In the absence of exact data, suppose the efficiency of this machine to be 93 per cent., two less than that of the small machine before considered; then we would have 5,040,860 foot-pounds per minute applied to the axis of the armature, or 152·75 horse-power, of which there was expended in the lamp circuit 123·15, in the external conductors 11·73, in the field circuit 2·22, in the armature 4·96, and wasted 10·69—*i.e.*, 80·6, 7·6, 1·5, 3·3, and 7·0 per cent. respectively. Although 4·96 horse-power may seem a large loss in the armature, it is a very small percentage on the whole; yet a diminution of ·0001 ohms would diminish the loss by 3,916 lbs. per minute. We thus see how absolutely necessary it is to have the lowest possible resistance in the armature when dealing with large currents, the energy of which, expended within a circuit of given resistance, increases with the square of the current. Were this same current, 945·36 ampères, to flow through an armature of a tenth of an ohm resistance, there would be a loss of over 118 horse-power, and were the resistance one ohm, nearly 20,000 foot-tons would be converted into heat per minute. In fact, it would be practically an impossibility to build an armature of this resistance to stand the current. Another instructive calculation may be made by reducing a armature to a nominal equivalent foot conductor. In this it is not necessary that we may compare with another machine to consider the relative intensities of the field. All machines have certain parts of the conductors which are inactive, and the less this proportion the better for the machine and higher its efficiency. In this generator there are 98 bars on the armature, the average length being four feet nine inches. The circle of revolution is 27·5 inches in diameter. At each end are 49 circular plates, each of these being the equivalent of a conductor 27·5 inches long. The speed of the engine is about 320 revolutions. From these data I find the useful part of the armature equivalent to a conductor one foot long, moving with a velocity of 15,682 feet per second, and the inactive part equal to a foot conductor with a second velocity of 6,507 feet, or the whole equivalent to a foot conductor with velocity of 22,189 feet per second. With an electromotive force of 111·67 volts this gives a foot conductor a second velocity of 198·7 feet per volt developed, and with 5,040,860 foot-pounds per minute, an absorption of 3·78 foot-pounds in a foot conductor per foot per second, of which 93 per cent. is developed into electrical energy. This is an admirable showing, and affords some data on which to build a still larger machine. I am inclined to think that were the armature built of rings instead of discs, even less power would be wasted. The limit to the size of machines to be built is reached when we determine how much waste can be afforded, and how much must of necessity be lost in the armature. The current generated is taken off by four pairs of independent brushes, the surface of the commutators being slightly amalgamated. The sectional area of the brushes on one side is about 4 square inches. The commutator blocks should be movable, and I understand all large machines now are so constructed. I have seen the largest machine here run one lamp of about 16 candles, and at other times 800 to 1,000 at from 20 to 25 candles, or even higher.

The potential is such that the commutator brushes can be readily grasped. The armature heats moderately—the radiation being hindered by a thorough insulation—but a blower forces air around it to prevent undue rise of temperature. The engine seems to me an excellent one, and now that certain opposition to large dynamos has been hushed, the engine becomes the moot point. The general experience has been that high speed engines on variable work and long runs have given a great deal of trouble with lost action, back lash, loosening nuts, and wear of piston, cylinder, valves, and guide-bars. In a large system of distribution the variation of load is much more gradual than in a tool shop or factory, and consequently the work is better adapted for a high speed engine than many other kinds might be. For large engines there may be urged less wear and tear, fewer individual parts to look after, less liability to a break down, a greater number of good engines to choose from, and higher economy. In favour of the higher speed engine, there is less boiler space required, the individuality of each engine, the less inertia, and in case of break down the disabling of a much smaller part of the plant. I confess to have had a prejudice against high speed engines, but this has mostly disappeared, and an inspection of one of the engines at Holborn Viaduct shows it to be in thoroughly good condition. The boilers are the Babcock & Wilcox patent, adapted to quick steam and high pressure. They need to be well taken care of, but are widely and favourably enough known to engineers to need no comment.

LAMPS.

On account of the need of having the external resistance high compared with the internal, and this ratio necessarily increases with the volume and current required; the resistance entering into a part of the lamps and not into others; the necessity for allowing a smaller illumination for different lamps; and from the fact that a given illuminating power can be obtained from a fine filament with a less loss of energy in conductors than from a coarse one, Mr. Edison has aimed at carbons of a very high resistance. There have been difficulties in the way by no means easy to surmount. One is that carbon diminishes its resistance when hot, another that strength, elasticity, and life are wanted. A third is that lamps of like illuminating power should have the same resistance and certain to last a reasonable time. Remarkable advance has been made, and 16-candle lamps are now made of 240 ohms resistance cold, and 140 hot, and 8-candle lamps of about 475 ohms cold and 275 hot, exceedingly strong and elastic, and of long average life. This life is still quite variable and it cannot be foretold, about 1,100 hours being their average at present. Made of the finest bamboo, they are fibrous, of very even texture and very fine. The carbons are joined to copper terminals of the platinum wires in the glass, the copper clamps and ends of the carbons being plated in a solution. The platinum wires are sealed in a hot press joint at the inner end of a tube sealed in the neck of the globe, whence copper wires lead to brass connections, which are brought into contact with similar connections in the socket. The carbons are so elastic that they will vibrate from one side of the globe to the other. When hot they are less elastic. For lamps of higher illuminating power the width of the carbon is increased while the thickness remains about the same. The use of two or more carbons is not a practical arrangement. This gives about double the illuminating surface, half the resistance, and requires double the energy. There is room for great improvement in the matter of lamps of high power, for I have no doubt that in the near future incandescent lamps of 200 or 300 candle-power and higher will be perfectly practicable. It has been said that lamps should have the highest possible resistance. This is not so. The carbons have been reduced about as far as possible in width. They may be made thinner, and thus a step made to lighter weight, higher resistance, and greater economy. But the real limit is the potential which can be used. The resistance of a carbon of given illuminating power must depend on the foot-pounds of energy expended and the potential at the terminals. The following table will show the resistances for several degrees of potentials and economy:—

Foot-pounds of Electric Energy used in Lamp per minute.	Number of Lamps per H.-P.	Candles per H.-P.	Resistance of Lamps in ohms when the Electromotive Force is in volts.				
			100	125	150	175	200
3,000	11	176	147	246	332	452	590
2,500	13·2	211·2	177	293	398	542	708
2,000	16·5	264	221	367	498	677	885
1,500	22·	352	295	489	664	903	1180

Already there has been produced about twelve lamps per horse-power, but I think that 2,000 foot-pounds of energy is as low as can be hoped for, and I do not feel that we should go above 150 volts potential at the lamp terminals. If this end can be obtained, the carbons must have a resistance of 498 ohms hot, and there will be produced over 260 candles per horse-power of electrical energy. I am confining these computations and statements to the case of lamps not giving over 16 candles, a standard of which the long use of gas has led to the adoption. The difference in work between a 140-ohm lamp at 15 and 16 candles power is about 84 foot-pounds, which will allow two ohms difference of line resistance for two lamps, *i.e.*, about 1,000 feet of No. 15 wire, or one mile of No. 8. Neither a high resistance nor a high potential is necessary to get a certain candle-power with a certain expenditure of energy in a lamp of given mass, but a greater current is necessary with the lamp of low resistance. This means a greater loss in the conductors, a less efficiency of generators, and a much more limited distribution. Let me illustrate by a particular instance. A current of 400 or 500 ampères flowing through a conductor an inch in diameter, exposed to the air, would heat it very appreciably, say, 15° C. above the atmosphere. Now, what are the conditions in a system of distribution? The cable must be thoroughly insulated, and hence there will not be a free radiation of heat, although surrounded by moist earth, and the rise in temperature will be fully as great as in the case of the exposed conductor. But copper increases its resistance ·4 per cent. for each degree of rise. Supposing our lamp to have but a fourth of the resistance; with the same economy double the current would be required. If the resistance of the cable were fixed, this double current would develop four times the heat, but the increased temperature is attended by a rise of fully 30 per cent. in resistance, and the work done would be more than five times as great. Further than this, the temperature of the cable would be dangerously high.

METERS.

After many trials of various kinds of meters, or registers, Mr. Edison has adopted that which depends on electrical deposition, and has selected pure zinc for his plates, a strong solution of sulphate of zinc for the liquid, and places the register in a shunt circuit, allowing but about 1-800th of the current to pass through it. The weight of zinc

deposited in one hour by the ampère of current is 1198·8 milligrammes. Polarisation is remarkably weak, and there is very little variation when a large number of the meters are tested together. Very careful weighing is necessary, and probably the popular desire to see for one's self what current one is using, and thus have a check on the readings of the company, could only be met, with this meter, by having a competent supervisor of the weighing who was in no way connected with the company. But in the meter economy and accuracy seem to have been the objects. Error from a change of temperature is almost entirely eliminated by a proper proportion of plates and solution, the resistance of which changes in opposite directions.

SAFETY ARRANGEMENTS.

Much has been said about the danger of fire from the introduction of electricity; but if the wires are properly laid, and means be taken to cut out a circuit, when for any reason a short circuit takes place, causing of course an instant increase of current, there is no cause for apprehension. All wires, besides being insulated, should either be run through the brick or stone of a structure or run along the walls, and covered by a moulding to prevent accidental joining of the two wires. Mr. Edison has adopted this plan. The switches have large bearing surfaces, and the contacts are broken sharply to prevent arcing. Aside from these arrangements, he has introduced a feature which is an absolute necessity, and which is now recognised essential to all systems of distribution for domestic purposes. This is a weak point in every main, derived, and sub-derived circuits—a bit of wire of lead and tin alloy, which is mounted in a plug and can be readily replaced when destroyed. In the event of a short circuit the sudden increase of current fuses this wire before it can possibly heat the copper conductors. This is, I think, one of the most admirable features in this system.

Having thus considered the principal points of Mr. Edison's system in detail, let us look at it as a whole. At the late Crystal Palace Exhibition there were about 1,075 mixed lamps distributed, all supplied by the same main conductors, and arranged in branch circuits with switches and safety plugs. These were equivalent to 840 standard lamps, and the current was supplied by twelve dynamos. One object in designing the plant was to get an independence of power such that the failure of any part would not cause extinction of the lamps. The motive power consisted of three Robey, non-condensing, double cylinder engines. Each fly-wheel gave motion to a loose pulley, which through a movable cone pulley drove a section of shafting to which were belted the dynamos. Thus the breaking of an engine would stop four machines only; two could be stopped by shifting the cone pulley, and one by throwing off its belt. This arrangement steadied the current, and minimised the effect due to any irregularity of an engine. With 70 standard lamps as the full work of a dynamo, one machine should be added to every 70 lamps added to the circuit, so that the relation of internal and external resistances should remain the same. The internal resistance was about ·017. The 12 pairs of field coils, like the machines, were in parallel circuit, making their resistance 3·46 ohms, and the external resistance was about ·17 ohms. The engines run at 120 revolutions, driving the dynamos at 1,150. The machines run very quietly, with very little sparking. In the field circuit was placed the regulator, a series of open wire coils joined to segments of a circle around which travels an arm which by successive contact throws into circuit one or more coils, thus increasing the resistance of the field circuit. By the movement of a lever the lights could be thus regulated in intensity. The eye is a very poor judge of this intensity, and to indicate an abnormal potential a magnet is bridged across the mains just as the lamp is done, and the tension of the armature spring regulated, so that when the potential increased, the increase caused the armature to move and a bell to ring. Such an arrangement, however, shows only the fact that the potential is too high, and in a larger system a much more delicate arrangement is used, the deflection of a spot of light on a graduated arc of large radius. The manual labour now used could be readily dispensed with, for the current in the galvanometer circuit can control a delicately adjusted armature, which being moved one way or the other would throw into action mechanism to operate the lever, or can close or reverse the current of a small motor, which moves the lever one way or the other. The use of the regulator should be as limited as possible, because a resistance which has no other function than diminishing a current is not to be commended, therefore very few coils should be in circuit for any length of time, and the regulator should find its office principally in meeting any sudden changes in the external resistance. The small amount absorbed in regulation, about the energy used in four lamps for a 70-light machine, cannot be objected to. Whether the shunt system, or the method of separate exciting for the field magnets will be found preferable, will probably be ascertained only after considerable experience. With but few machines in action, I think unquestionably the shunt system, with comparatively high resistance of the field coils, is by far the best. These are matters of relative economy and practice, not at all of the successful distribution of electricity. Just as small machines may be coupled in parallel circuit, so may large ones, with satisfactory results. This coupling of machines of low resistance in parallel circuit is absolutely necessary, and the only way practicable for a system of distribution directly from the generators. When so joined, loss of energy in the armatures bears precisely the same ratio to the total energy expended as exists in a single machine. Were the lights at the Crystal Palace furnished by one machine, having an armature with a resistance equal to that of one of the armatures of the small machines, there will be a loss of over 90 horse-power, enough to drive nine machines. When the machines are joined, there is the same immunity from harm in case of contact as in a single machine.

At Holborn Viaduct there are from 1,100 to 1,150 lamps furnished from the central station. The system of distribution is that of multiple arc and branch circuits. It is this question of distribution over large areas to which Mr. Edison has given a great deal of thought, and has, I think, satisfactorily solved the problem. Imagine two great sheets of copper in juxtaposition, maintained at a certain difference of potential. If in either there exists a difference of potential at any two points there will be a general flow of electricity set up to restore the plate to a state of equilibrium. If these plates be joined by conductors, currents will flow proportional to the difference of potentials and the resistance of the conductor, just as if these plates were the terminals of a machine. Let such plates be the terminals of a machine, or, better still, of several machines, and let the connections be made at several points. There would be a system of distribution, as far as regards the conductors, on the most perfect principles; and if the resistance of the connecting paths is less, that is, the number of paths greater, at one point than at another, there would be at that point a greater tendency to reduce its potential, and currents would flow to it from the surrounding parts. Perforate these plates, or replace them by networks, or meshes of cables, and we have a perfectly practicable method of providing a distribution, and I think the most satisfactory one. The way of laying down a district on this system is to lay the main cables in each street, and wherever they cross join like to like. This is to be supplied from the central station at several different points, which points are determined by the relation of the size of the conductors and the resistance of, and allowed variation in the intensity of the lamps. The direction of the current in the street conductors will not always be the same, but will change so that the maximum flow is towards the point where there is the greatest demand. The relative sizes of conductors are calculated for the maximum currents they are to carry, and in order that the percentage of loss may be the same a double current would require a conductor of double cross section. The main conductors diminish in size as the distance from the several sources of supply increase, and the several districts in the city, each being primarily fed by a single system of generators, are joined together. If one-half of these conductors were broken the remainder could still supply the district. Small wires from every part of the city can be taken to one central office so that the actual state of the potential may be known at any instant at any point, and even an automatic record kept. Thus one man can keep constant supervision over the whole system, having thus a check on the engineers, and by telephonic communication give the necessary directions to increase or lower the supply. In every dynamo room a dial can be placed in a shunt from the cable of each machine which will indicate the number of lamps or the amount of current which the machine is supplying. I have made no mention whatever of the application to power, which I will consider later. Nor have I spoken of storage batteries in connection with this system, and I think with Mr. Edison that they are not a necessary adjunct. The variation of light would be remarkably small, and the failure, as far as the street mains are concerned, is practically impossible. There then remains the question: What is the liability of break down at a central station? If there is but one such station, the only way in which it could be disabled would be the blowing up of the major parts of its boilers, and this is not very probable. The break down of a single engine, the failure of one or two armatures, is quite possible, and we may say at times probable. But such a breakage would not seriously affect the supply, for, aside from the fact that there would probably be a reserve dynamo, the machines can be easily run to over their normal power. In a city the entire destruction of a central station would not put out the lights in its own district, for the mains would be supplied from those of the surrounding districts. The calculation of the size and number of the supply and distributing means is a work of most careful engineering. It involves the cost of iron and copper, of coal and property, of labour, of capital invested and interest required—in short, how much of the energy of the coal can be wasted, and in what part of the system. So each city must be the subject of special calculation, and, although a complicated work, it is perfectly practicable.

Such is a brief *résumé* of Mr. Edison's system, as it has appeared to me after long and thorough study, a system in the fullest sense of the word—one of supply, measurement, and consumption, elaborate in detail, broad in conception. When we consider the present uses of electricity, and the uses which will be developed when it is at every householder's command, we will be more able to appreciate the importance of Mr. Edison's work, and recognise his clearness of conception and great foresight in thus practically solving the great problem of the distribution of electricity.

(*For discussion on this paper see page* 179.)

A NEW ELECTRICAL CONTACT MAKER.

[Paper read before Section A, Tuesday, August 29th, 1882,
By Prof. H. S. HELE SHAW.]

THE author first calls attention to the want of an absolutely reliable and at the same time sufficiently sensitive electrical contact maker. Such an instrument is often required to measure or control the relative motion of bodies in conjunction with delicate clockwork. He then proceeds to discuss the ways in which such contact may be made. In theory there is no distinction in the modes of doing this, but practically they may be separated into—

(1.) Relative motion of the two terminal surfaces normal to both.
(2.) Motion tangential to both.
(3.) Motion compounded of these two.

These modes are separately discussed, and also the various objections with all when solid terminals are used. The use of a liquid terminal with which the other terminal being solid is brought into contact obviates most of these objections. Of all liquids mercury is the only one which can practically be employed. There are, however, two

objections to its use which have prevented its being hitherto adopted for more than temporary and experimental purposes. These are:—

(1.) The fact that it readily combines with oxygen on the passage of the electric spark.

(2.) The difficulty of making a contact maker of this kind portable.

The earliest form of instrument in which the author has endeavoured to overcome these difficulties, was then shown on a diagram and described. Its principle of action is briefly this: A short glass tube, closed at the upper end (such as an inverted test tube), is filled with mercury and inverted in a vessel of mercury. The mercury in the tube is then partially displaced by hydrogen gas. A very light bent lever, consisting of a platinum wire, passes through the mercury into the gaseous space, and there makes contact between the mercury below and a smaller quantity of mercury in an insulated capsule above the other portion, but within the tube. This lever works on a pivot, being actuated from the outside by the escapement of an ordinary clock, and is extremely sensitive in its action. The positive and negative poles of the terminals are respectively connected with the mercury in the capsule, and that in the vessel below. It is evident that although the lever is always in electrical contact with the latter, the circuit is only completed when it is brought into contact with the former. Accounts of experiments showing the satisfactory action with this apparatus are then given. Finally, the most recent form of apparatus which is portable is illustrated and described.

RECENT PROGRESS IN TELEPHONY.

[Paper read before Section G, Monday, August 28th, 1882,
By WILLIAM HENRY PREECE, F.R.S.]

THE telephone was first introduced to the British public at the meetings of the British Association. In 1876, at Glasgow, Sir William Thomson startled all his hearers by announcing the fact that he had heard, in Philadelphia, Shakespeare quoted through an electric wire, by the aid of the invention of Mr. Graham Bell, which he then pronounced to be "the greatest by far of all the marvels of the electric telegraph." In 1877, at Plymouth, I had the pleasure of showing in actual operation the finally developed instrument now known as the Bell Telephone, which I had just brought over from America, and conversation was actually maintained between Plymouth and Exeter. Five years have elapsed since then, and it is fitting that the British Association should hear of the progress made in the application of this astonishing apparatus.

In 1877, it was simply a scientific toy; it has now become a practical instrument. £1,550,000 capital is already embarked in its extension in England, and it is earning a revenue of £109,000. Hitherto it has been practically a monopoly in the hands of a private company, who hold the controlling patents, and of the Post-office, who possess the controlling power, but owing to the policy of the present Postmaster-General, this monopoly has been broken up, fresh patents have come into existence, and we are about to witness severe competition. It is often said that competition in any business will have the effect of reducing the rates charged to the public, but the experience of the past in railways and telegraphs scarcely teaches this lesson; competition does not always benefit the public. Undue competition tends to lower the rates for a time, but it eventually leads to amalgamation, to the absorption of the weak by the strong, to swollen and watered capital, and finally, in many instances, to higher rates to a too-confiding public. Competition however induces better service, and ultimately, in this respect, the public gain.

The free traffic in patents, however, leads to jobbery and speculation of the worst type. We have recently seen a mania for electric speculations that almost rivals the South Sea Bubble period. The public have wildly rushed into ill-matured schemes that have swollen the purses of gambling promoters, have turned the heads of inventors, have retarded the true progress of the beneficial application of this new science to the wants of man, and have thrown away millions upon imperfect schemes. Much has been said against the monopoly of the Post-office in telegraphic business, but it has, at any rate, the merit that it has checked the rapacity of company promoters and patent-mongers in that branch of the practical application of electricity, while no one can assert that it has checked the progress of telegraphy. During the first week that the telegraphs in this country were transferred to the State, the total number of messages transmitted was 26,000, while in the week ending August 11th, it amounted to 724,000. There is no inventor who can assert that his scheme has not received proper consideration, nor show a real improvement that has not been adopted and remunerated; while the improvements of the Post-office itself are freely adopted by other countries, and America itself, the home of the inventor, has found the advanced system of England worthy of acceptance.

Receivers.—The original telephone receiver of Bell has scarcely been improved upon; it remains in form and construction very nearly the same as that which I exhibited in 1877. The perfection of its working depends upon the truth and perfection of its manufacture. It is now more solid and substantial than it was at first, more powerful magnets are used; but still it is the same simple, marvellous, and beautiful instrument that I brought over from America. Mr. Gower has increased its loudness by varying the form of its various parts, and using very powerful horse-shoe magnets of peculiar form; but experience shows that loudness is always obtained at the expense of clearness of articulation; and, although for many purposes the Gower-Bell instrument, which is adopted by the post-offices, and is now in use to connect together all the sections of the British Association scattered through the town of Southampton, is more practical, nothing for delicate articulation surpasses the original Bell.

The Paris Exhibition of last year, so fruitful in electrical novelties, did not bring forth any marked improvement in telephonic apparatus. It was noticeable chiefly for its practical applications of the telephone, and particularly to the transmission of singing and music to a distance. M. Ader's modification of Bell's receiver is that almost universally used in Paris. It is a very handy, pretty, and convenient form. He utilises a principle which he calls "surexcitation." A thick ring of soft iron is inserted between the ear-piece and the diaphragm, and this is said to increase the attractive power of the little horse-shoe magnet upon the vibrating iron diaphragm. A simple experimental apparatus of M. Ader's shows that there is some foundation for this fact: when a thin steel spring is adjusted close to the poles of a magnet without being attracted by them, the near approach of a mass of iron to the spring will cause it to be attracted by the magnet.

D'Arsonval has also modified the Bell receiver. He has placed the coil in a powerful magnetic field of annular form, and has thereby concentrated the lines of force upon the induced coil. He brings the whole coil within the influence of the field. The effects are considerably magnified, and the increased loudness is not accompanied by the usual loss of articulation. Speech is said to be reproduced without any change of *timbre*.

Telephone receivers of the Bell type are all based upon the magnetic effects of currents of electricity flowing around magnets or bars of soft iron.

The rapid and rhythmic magnetisation and demagnetisation of a bar of iron, or the increment and decrement of the magnetism of a magnet, will produce molecular disturbances, in its own mass and in the matter about it, that lead to the oscillatory motions of the whole, which produce sonorous vibrations that can be made manifest by various devices, and particularly by that patented by Graham Bell.

Other principles of electricity have also been utilised for telephonic receivers.

For instance, Mr. Edison used the electro-chemical effect. The decomposition of a chemical solution in paper or on chalk by the passage of currents through it produces a modification of the friction of two moving surfaces, which can reproduce sonorous vibrations, and the result is a very loud-sounding apparatus. I myself had the pleasure, in 1880, of submitting to the Royal Society a receiver based on the electro-thermal effects of the current. The passage of a current through wires always heats them and therefore produces expansion. If the wire be made fine enough, the heat is generated and dissipated so rapidly, the expansion and contraction are so quick, that sonorous vibrations are the result. Although I was able to speak through it very clearly, I have not as yet developed this instrument into a practical form. Professor Dolbear has recently utilised the electro-static effects of currents. His receiver is even more simple than that of Bell. Two flat circular discs of metal are rigidly fixed very close to each other in an insulated case of ebonite. When one disc is electrified positively by a charge of electricity, the other is electrified negatively by induction. These two opposite states produce attractions varying in force with the strength of the signals sent, and the result is that, when telephonic currents are transmitted, we obtain sonorous vibrations, and consequently, the reproduction of speech.

Many other forms of telephone receivers have been devised and exhibited, in fact I have recently seen quite a crop of them; but as they involve no new principle, and introduce no particular improvement, having been brought out chiefly to try to avoid existing patents, I pass them over, and proceed to the next branch of my subject.

Our present Patent Law is, unfortunately, in so disorganised and chaotic a condition that evasion is often possible, and hence the questionable morality of doing a thing in another way in order to avoid the incidence of a royalty, is practically encouraged.

The possession of a patent is now no guarantee of property: it is granted without any discrimination, and cannot be upheld without tedious litigation and wasteful expenditure before a non-technical and scientifically incompetent tribunal. We therefore cannot hope for any virtue in English inventors or security for real improvements until our law is thoroughly revised. The question is before the House of Commons, and when wordy agitators have fully exhausted the patience of our legislators, we may hope for some attention to so real and pressing a want.

Transmitters.—The great novelty and peculiarity of Bell's telephone was that the receiver and transmitter were similar and reversible. Sonorous vibrations of air impinging on an iron disc caused it to vibrate in front of a magnet, around one pole of which a portion of an electric circuit was wound. These vibrations of a magnetic substance in a magnetic field produced currents of electricity in the coil of wire on the magnet, varying in strength and direction with the sonorous vibrations, which, proceeding along a wire to a distant station, there varied the magnetic strength of a similar magnet so as to vary its attractive force on a similar disc, by which it reproduced the motions of the first disc, and thus, reproducing the sonorous vibrations of the air, repeated speech. The currents, however, were very feeble; much energy was lost *en route*, and the effect scarcely attained a practical standard. Mr. Edison showed how to strengthen these currents. Taking advantage of a peculiar property of carbon, which was supposed to vary in electrical resistance with the amount of pressure brought to bear upon it, he caused the vibrating disc which was spoken against to press upon a button of carbon, and so to vary the strength of a current of electricity passing through it. This varying current, passing through the primary wire of an induction coil, set up in the secondary coil more powerful currents than the Bell instrument produced, and caused louder and more marked effects at the receiving station. Professor Hughes went a step further. He found a combination of materials that were directly affected by sonorous vibrations, which he called a "microphone," and he proved that the effect of the carbon transmitter of Edison was not due to any influence of varying pressure on the mass of the carbon, but was a phenomenon of loose contact. He found a new fact in nature, and

he startled the scientific world by introducing an instrument which did for minute sounds what the microscope had already done for minute objects. By the light thrown on the theory of the instrument by Hughes, Edison's carbon transmitter has been so improved by Blake, Hunnings, Moseley, Anders, and others, that little apparently remains to be done. The telephone as a speaking instrument is now well-nigh perfect. It is quite possible to swear to a friend's voice at 100 miles distance. The difficulty of making the telephone a practical instrument under all circumstances is not due to any defects in the instrument itself, but to disturbing influences external to it, and consequent on its surroundings. The very perfection and sensitiveness of the apparatus itself are its chief enemies.

The true action of the microphone, or carbon-transmitter, is very little understood: it introduces into a closed electric circuit, through which a current is flowing, a resistance which, varying exactly with the sonorous vibrations impinging upon it, causes the current to undulate in a way exactly analogous to the varying sound waves. This effect is generally assumed to be due to a greater or less intimacy of electrical contact between two semi-conducting surfaces abutting upon each other; but there is now little doubt that it is due to effects of heat generated by the passage of electricity between two points in imperfect contact, whose relative distance is variable. Carbon is the best material for the purpose—first, because it is inoxidisable and infusable; secondly, because it is a poor conductor; and thirdly, because it has the remarkable property of having its resistance lowered when it is heated—the reverse of metals. This observation is due to Mr. Shelford Bidwell.

The resistance of microphones is very variable: some only give 10, while others give 25, and some even 125 ohms. The best transmitters that I have worked with (Moseley's) give an average of 20.

Attempts have been made to apply mathematical analysis to the determination of the best form and arrangement of microphones, but at present the microphone defies mathematics.

Theory would lead to the conclusion that a carbon transmitter should have the lowest possible resistance, but practice does not confirm that idea.

Theory again asserts that the resistance of the secondary coil of the induction coil should be equal to that of the line it works, but practice proves the very reverse. On a line giving nearly 1,800 ohms resistance, the best effects were produced with a secondary wire of only 30 ohms resistance. The fact is that the conditions due to heat in the microphone, and to self-induction in the induction coil, are very complicated, and are not yet sufficiently understood to bring the phenomena they affect within the region of mathematical analysis.

Accessories.—I do not intend to speak here of the bells, calls, switches, &c., used in carrying out telephonic operations: there has been nothing that is particularly novel introduced, or that was not previously used in telegraphy. In fact, the whole operations carried on in connection with the so-called "exchange" working are simply telegraphic, and are still in a somewhat tentative condition.

Long-distance Speaking.—I have said that the difficulty in speaking is chiefly due to the environment of the wires employed. Were we to erect a wire from Land's End to John o' Groats, upon lofty separate poles and away from all other wires, there would be no difficulty whatever in speaking between those two places. Conversation has been held in America over 410 miles; in Persia it has been effected between Tabreez and Tiflis, 390 miles apart; in India, over a distance of nearly 500 miles; in Australia, of 300 miles; but in all these cases it was done either at night or under exceptional circumstances, and in all cases the wires were overground. Had they been underground or submarine, the case would have been very different. Conversations have been held between Dover and Calais, between Dartmouth and Guernsey, and between Holyhead and Dublin, but I know of no case where any persons have spoken through more than 100 miles of submerged cable. The reason of this diminution of speaking distance is due to the electro-static capacity of the telegragh line, which absorbs the minute quantity of electricity that makes up the currents employed for telephonic purposes.

In every submarine cable, before a signal can be made at the receiving end, the whole cable must be charged up with electricity, and if there be not sufficient electricity sent in to effect this purpose, practically no signal appears at the distant end. With telephone currents on long cables the whole of the electricity is, as it were, swallowed up—that is, none appears at the distant end, or, if it does appear, it is rolled up in one continuous wave, bereft of those rapid variations that reproduce sonorous vibrations. The newspapers said that the sound of the bombardment of Alexandria was heard at Malta; but, in the first place, the experiment was not tried, and, even if it had been tried, it could not have succeeded. The use of underground wires very seriously impedes telephonic extensions, and with our present apparatus and present knowledge we cannot readily speak over greater distances than 20 miles.

Disturbances.—But there are other disturbing influences at work of more serious import.

When two or more telephone wires run side by side, what is said on one can be overheard on all the others; and when a telephone wire extends alongside telegraph wires, every current on the telegraph circuit is repeated in the telephone, leading to a hissing, frying, bubbling sound that is not only very irritating, but which on busy lines entirely drowns speech. When music is transmitted on one wire, it can be heard equally well on all wires running parallel and contiguous. This is due to induction and to leakage.

(A.) *Induction.*—Induction is a term employed to designate the peculiar influence which electrified and magnetised bodies exert upon conducting and magnetic masses in their neighbourhood. If two wires run side by side for some distance, every current of electricity sent upon one wire will produce two currents in the contiguous wire, the one at the commencement and the other at the end of the primary current of electricity. The greater the intensity, and the more sudden and abrupt the commencement and the ending of the inducing current, the greater effect it has on the induced wire. Those instruments, consequently, which reverse their currents the most rapidly and suddenly, produce the greatest disturbance. The powerful alternative and intermittent currents used for certain electric light systems are death to telephones: they cause an incessant roar that renders speech an impossibility. There are some apparatus in telegraphy that require very powerful currents to work them, which are equally detrimental. Many attemps have been made to cure this evil.

1. The sensitiveness of the receiver has been reduced to lessen the influence of the disturbing currents, and the strength of the telephonic transmitting currents has been increased so as to overpower the induced currents.

2. The influence of one wire on the other has been screened off by inserting metal coverings in connection with the earth between them.

3. The suddenness of the rise and fall of the inducing currents has been modified by the insertion of condensers or electro-magnets.

4. Counterbalancing or neutralising effects have been set up by counter-induction apparatus.

But all these plans, and many others, have been proved either only partially successful or wholly abortive; the only effective mode of curing the evil at present practically used is to employ a complete metallic circuit, so contrived that the two wires are in very close proximity to each other, or that they twist round each other, so as to maintain a mean average equality of distance between themselves and the disturbing wires. When we have the two wires of a circuit kept at the same mean distance from the disturbing causes, however near they may be, the influence on each must be identically the same, and as the one is used for going and the other for returning, the similar influences must be opposite in direction, and they must therefore neutralise each other. This plan, which was originally devised for underground wires by Mr. Brookes, of Philadelphia, was found to be absolutely true in practice, and the Post-office, having laid down many hundreds of miles on this system with perfect success, invariably constructs its circuits both underground or overground in this way. It is, of course, more expensive than a single wire, but the great gain—the absolute freedom from overhearing the privacy, and the absence of crackling—is well worth the extra cost. Wires in submarine cables are invariably laid up with a twist, so that no special contrivance is needed on such wires, and in underground wires not laid up together as cables, they are, as a rule, so close to each other that twisting is unnecessary; but for overground purposes twisting is essential, and special arrangements have to be carried out. Professor Hughes showed how this was to be done, and Messrs. Moseley carried it out practically in the neighbourhood of Manchester. The plan adopted by the Post-office for *two* and for *four* wires is shown by the diagram. It is simply and easily carried out, and entails no practical difficulty whatever.

In the neighbourhood of Manchester there are over 400 miles of overground double wire twisted on this plan, working efficiently and thoroughly. I have spoken to a friend 76 miles off, through wires that were erected on poles carrying busily-occupied telegraphic currents, without disturbance or difficulty.

(B.) *Leakage.*—The double-wire system is only absolutely effective so long as the insulation is good. The moment insulation fails, connection with the earth is made, and then we have disturbing causes, due to currents flowing through the ground, which are increased in proportion to the deterioration of the insulation. Hence, good insulation is essential to telephone working.

The discovery of the telephone has made us acquainted with another phenomenon. It has enabled us to establish beyond doubt the fact that currents of electricity actually traverse the earth's crust. The theory that the earth acts as a great reservoir for electricity may be placed in the physicist's waste-paper basket, with phlogiston, the materiality of light, and other hypotheses. Telephones have been fixed upon a wire passing from the ground floor to the top floor of a large building, the gas pipes being used as a return, and the Morse signals sent from a telegraph office 250 yards away have been distinctly read; in fact, if the gas and water systems be used, it is impossible to exclude telegraphic signals from the telephone circuit. There are several cases on record of telephone circuits miles away from any telegraph wires, but in a line with the earth terminals, picking up telegraphic signals. When an electric light system uses the earth, it is stoppage to all telephonic communication in its neighbourhood. The whole telephonic communication of Manchester was one day broken down from this cause, and in the City of London the effect was at one time so strong as not only to destroy telephonic communication, but to ring the bells. A telephone circuit using the earth for return acts as a shunt to the earth, picking up the currents that are passing, in proportion to the relative resistances of the earth and the wire. The earth offers resistance, and consequently obeys the law of Ohm; hence it is not only essential for a telephonic system that the earth should not be used on any electric light system, but it is also desirable that the earth should be eschewed for telephonic purposes. Thus, the double-wire system adopted by the Post-office and by the Société Générale des Téléphones of Paris, not only cures the ill-effects of induction, but it materially diminishes the disturbing influences of earth conduction. The four-wire system of the Post-office effectually checks leakage from one wire to the other, cross contact, as we call it in England, for each wire of the same current is always on a different supporting arm.

A telephone circuit when in connection with the earth gives distinct evidence of every visible flash of lightning, however far off the thunderstorm may be. No difference in time has been observed between seeing the flash and hearing the crash.

It is said that if a telephone be connected between the gas and water systems of a house, distinct evidence of every flash can be heard. There have been several cases of persons being knocked down while experimenting during a thunderstorm, but no personal injury has been sustained, although the apparatus itself is frequently damaged. In England, at present, we have not found the damage done sufficient to justify the employment of lightning

protectors. The use of double wires diminishes the danger to a minimum. On the Continent and in America, however, telephones are invariably protected by lightning arresters where one wire only is used.

There are certain natural currents flowing through the crust of the earth. They are called "earth" currents, and at times acquire such considerable energy that with a telephone pressed to each ear, I have been told, although I have not experienced it, that the noise made is as though "your brains were boiling." This is due to the intermittent currents produced by the polarisation of the earth plates.

M. Van Rysselberghe has recently spoken between Paris and Brussels upon a wire nearly 200 miles long, which was used at the same time for ordinary telegraphy, but the experiment was made early in the morning (4 a.m.), and was effected by retarding the telegraphic currents, so as to modify the suddenness of their rise and fall, by means of condensers and electro-magnets. I am unable to understand the advantage of any gain in speaking on a wire which is detrimental to telegraphic communication. Speed is of more importance than speech, and we can telegraph much faster than we can speak. In England speed is everything, and we eliminate every influence that retards speed—condensers and electro-magnets in telegraph circuits are out of the question. M. Van Rysselberghe has endeavoured to extend the idea to cure the effects of induction by destroying the main cause of the disturbance—that is, by reducing the sudden rise and fall of the prime telegraphic currents; but to do this means to retard telegraphy, and we cannot afford in England to cripple the one system in order to benefit the other.

I have recently tried an extremely interesting experiment between this place (Southampton) and the Isle of Wight, namely, *to communicate across seas and channels without the aid of wires at all*. Large metal plates were immersed in the sea at opposite ends of the Solent, namely, at Portsmouth and Ryde, six miles apart, and at Hurst Castle and Sconce Point, one mile apart. The Portsmouth and Hurst Castle plates were connected by a wire passing through Southampton, and the Ryde and Sconce Point plates by a wire passing through Newport; the circuit was completed by the sea, and signals were passed easily so as to read by the Morse system, but speech was not practical.

The telephone is very rapidly gaining ground, and as improvements are effected in its accessories, in its installation, and in its mode of working, its use will still further extend. In Germany it is used very extensively for telegraphic business, there being 1,280 stations worked entirely by telephones, but in England it is not possible in the numerous open and public shops employed as post-offices to secure that privacy which the telephones require, nor have we yet got over our early prejudices, resulting from the errors made through the inability of the instrument in its earlier form to repeat the sibilant sounds. The instruments of the present day (thanks to the improved transmitters), however, transmit "s's" perfectly. By Mr. Smith's inductophone it is quite possible to make use of air between us to hear perfectly; so that air conducts sound, so does water, so does wire, and indeed with our present knowledge our difficulty is not so much to make things speak as to prevent them from speaking.

THE DEMANDS OF A SYSTEM OF ELECTRICAL DISTRIBUTION.

[Paper read before Section A, Friday, August 25th, 1882, By F. J. SPRAGUE, U.S. Navy.]

IN order to more fully understand the subject of incandescent electric lighting, let us consider the requirements graphically. I hardly need to argue that the multiple arc system is preferable to that of the series, and is in fact the only admissible one which can have any wide application. In fig. 1, let M be the generator, p and p' the terminals, R, R', R'', R''' circuits in multiple arc or parallel circuits; in other words, derived circuits from the same terminals. Now it matters not what the resistance of the machine, or the number, or resistance of the derived circuits, if they be connected to the same terminals, the current in any circuit will be equal to the difference of potentials at the points, p, p', divided by the resistance of the circuit in question. Nor does the addition or subtraction of any number of circuits make the slightest difference in the currents flowing in the circuits already established if this difference of potentials, $p - p'$, is kept constant. Consequently, the currents over the different paths will be inversely proportional to their resistances, and perfectly independent of each other. Since the external resistance diminishes with the increase in the number of the derivation circuits, the whole current flowing from the terminals will vary inversely with the external resistance. But the whole current is the current flowing through the armature. Since the internal resistance enters as a factor, although the difference of potentials at the terminals remains constant, the electromotive force of the machine does not. Let us consider a machine which, with an external resistance equal to the internal a, a given velocity and strength of field current, generates an electromotive force, ϵ. Call the external resistance $a\,r$, i.e., some ratio r of the internal, and let the current in the field magnets, independent of the current generated, or the velocity, or both, be changed as the external resistance changes, so that the difference of potential at the terminals may remain constant. Consider the change in the electromotive force of the generator. We have for two external resistances, one, a, equal to the internal, another, $a\,r$, greater or less, two currents.

$$c = \frac{\epsilon}{2\,a} \quad \text{and} \quad c^1 = \frac{\epsilon^1}{a\,(1+r)}$$

whence

$$\frac{c}{c^1} = \frac{\epsilon\,a\,(1+r)}{2\,a\,\epsilon^1} = \frac{\epsilon\,(1+r)}{2\,\epsilon^1}$$

But by condition of working

$$\frac{c}{c^1} = \frac{a\,r}{a} = r$$

$$\therefore \quad r = \frac{\epsilon\,(1+2)}{2\,\epsilon^1}$$

$$i.e., \quad \epsilon^1 = \frac{\epsilon\,(1+2)}{2\,r} = \frac{\epsilon}{2}\left(\frac{1}{r}+1\right)$$

Differentiating this last equation with ϵ as the unit of electromotive force and ϵ^1 and r variables, we have—

$$\frac{d\,\epsilon^1}{d\,r} = -\frac{\epsilon}{2\,r^2}$$

and

$$\frac{d^2\,\epsilon^1}{d\,r^2} = \frac{\epsilon}{r^3}$$

which give the character of the curve of electromotive force under the conditions assumed. Fig. 2 gives the curve, with r and ϵ^1 as the

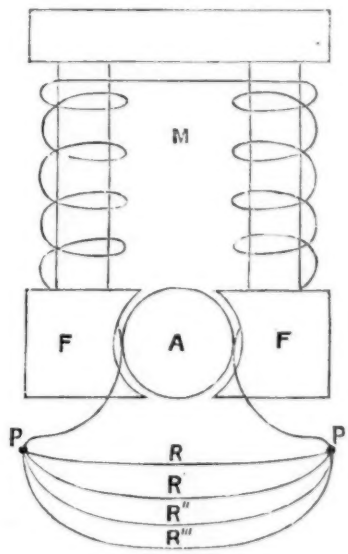


FIG. 1.

co-ordinates, x and y, with the bend near the origin, and with branches having for asymptotes the axis of y, and a line parallel to the axis of x, and distant $\frac{\epsilon}{2}$ from it. Vertical lines on to the axis of x represent the electromotive force compared with the unit, ϵ, which may

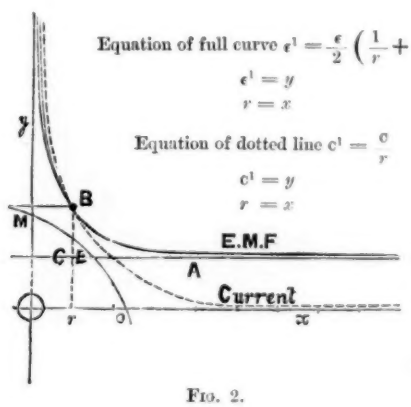


FIG. 2.

be of any number of volts, and the distance from the origin the ratio of the external to the internal resistance. This curve shows some important truths, a part of them familiar, others perhaps not so, concerning the economy and practice of the distribution of electricity, or the supplying of currents which will be inversely proportional to the resistance of the derived circuits, remembering meanwhile that the electromotive force of a machine excited by a separate circuit is very nearly proportional to the strength of the free magnetic field and the velocity of the armature. Of course this is somewhat affected by the heating of the metallic conductor for an increased current, the consequent change of resistance, the displacement of the magnetic field, and the heating of the iron part of the armature, if iron enter as a component. We notice

1. In a single generator the electromotive force is not proportional to the number of lights or motors, or the current developed.

2. No matter how high the external resistance, or how limited the number of derived circuits, the electromotive force of a machine required to maintain a fixed difference of potential at the terminals can never be less than half that developed when the external and internal resistances are equal.

3. The increase of electromotive force required as the external resistance decreases, or the number of derived circuits is increased, is very gradual up to the point where the external resistance is three or four times the internal, beginning then to rise more rapidly.

4. When the external resistance falls below the internal, the rise is very rapid, and if their difference is marked, then it becomes impossible to maintain a fixed difference of potential, because of the great increase necessary in the strength of the magnetic field and the velocity of the armature. A great amount of heat, and consequently of wasted energy, would be developed in the armature.

Let us consider another curve. Our requirements demand that the whole current should be inversely proportional to r, the ratio of external to internal resistance, or C being the current developed when the electromotive force is ϵ, $C^1 = \frac{C}{r}$. Let this curve be traced on the same axes as the preceding, and let the same unit of measure be used for C as for ϵ. (See dotted curve in fig. 2.) We find the curve somewhat similar to the curve of electromotive force; but it approaches both axes as asymptotes and falls rapidly below the first curve on the right, while rising above it on the left. A glance shows the relations of current and electromotive force for different ratios of external to internal resistance.

Note one curve more on the same sheet, though not with the same units; the curve of magnetic strength (M) is measured here vertically, the increase of field current being measured horizontally and to the left. The strength of the magnet increases at first quite regularly; the curve, however, flattens more and more as the current increases, until at the point of practical economic saturation a large further increase of the field current would produce but a much smaller ratio of increase of magnetic strength. Part of the energy of the increased current would undoubtedly manifest itself in heat both in the coils and in the iron of the magnet.

Now in a general distribution of electricity, a large number of derived circuits existing, there must necessarily be a low external resistance. Large currents flow through the generator, and we wish to have the energy of the current in the external circuit and not in the machine. It has often been said that the external resistance being thus reduced, the resistance of the individual lamps should be as high as possible. This is not so, for certain relatives exist between the weight and resistance of carbons, the illuminating surface, the electromotive force and current required, and the energy expended, which determine a limit. The expression for the work done is $\frac{\epsilon^2}{R} \times 44{\cdot}24$, or $C^2 R$, 44·24. Hence, with a given electromotive force the work done varies inversely as the resistance, and with a given resistance the work varies as the square of the electromotive force or the square of the current. If we increase the resistance to any ratio, d, of a given resistance, to maintain the same expenditure of force, we increase the electromotive force, but only in the ratio $\sqrt{d}$; so that with four times the resistance only twice the electromotive force would be required. Consider for a moment the size and shape of the carbon. If a carbon of circular form be used, the same weight would enter in a piece of half the diameter and four times the length of a given piece, giving sixteen times the resistance and twice the illuminating surface. With half the weight, we have the same surface and eight times the resistance. If the same energy be expended there will be necessary $\sqrt{8}$ times the electromotive force used with the coarse carbon, but $\frac{1}{\sqrt{8}}$ of the current. This would mean that with the same lamp expenditure for given illumination, one ton of coal would be used on the conductor for the high resistance lamp to eight tons for the low resistance one, a strong argument in favour of high resistance carbons.

Our first conclusion would then be to diminish the diameter and increase the length and resistance of the carbon, meeting this increase by an increased electromotive force. But in a system of general distribution, safety from fire, due to piercing the insulation, abnormal increase of current when short-circuited, and immunity from harm when by any accident the body forms a part of the circuit, demand a low electromotive force. Sir W. Thomson has said that this should never exceed 200 volts. Even this will give some persons a disagreeable shock, and a lower electromotive force may be used with advantage. Another point of consideration is the increasing of the resistance of a carbon while the length, diameter, and weight remain constant. As before, we see that the electromotive force must increase as the square root of the ratio of increase of the resistance, and this resistance must be determined by the limit of electromotive force, the size of carbon that can be manufactured, and the degree of illumination required. We will call this carbon, the carbon of smallest section, highest resistance, and standard illuminating power, the standard lamp. Now, while we have this standard, it is evident that we want to be able to increase the power of illumination at sundry points, and this must be produced, not by a corresponding increase of intensity per unit, but by an increase of the illuminating surface, and the increase of energy expended should be in no greater ratio than the increase of light. These remarks are partially founded on the fact that an increased temperature shortens the life of a lamp, and that the most reliable results are to be obtained by having carbons for all degrees of power of the same texture, and made by the same process as the standard, which standard should in every way be as near perfect as possible; all such carbons to have the same weight, length, degree of carbonisation, resistance, requiring the same electromotive force and expenditure of energy. For the lamps of higher power, we manifestly cannot use a carbon of greater length and correspondingly higher resistance, for this means a higher electromotive force, which is out of the question. Nor can we economically increase the diameter of a circular section carbon, for the resistance diminishes inversely as the square of the increase of the illuminating surface of same intensity. There are three ways where each lamp should be independent. One is by increasing the number of carbons in a lamp, they being arranged in parallel circuit; another by increasing the width of the carbon while the thickness remains the same—in other words, use a flat carbon, so that the illuminating surface will increase in the same rate as the weight of material. Now, with a double illuminating power we use the same texture of carbon, the same temperature and intensity per unit of surface, double the illuminating surface, one half the resistance, the same electromotive force, double the current and double the energy. A third method is that the carbon can be increased in length, while its resistance per unit of length and section is diminished.

Aside from the energy expended in the lamps and motors of a circuit a certain amount goes into the generator to magnetise the field magnet, and this is represented by the same expression we have already used where the difference of potential at the terminals of the machine and the resistance of the field coils enter as factors. There is another expenditure in the armature coils and the conductors dependent on their resistance and the current flowing, and still another at the commutator, which would be greatest with large currents. The friction of bearings, the slipping of belting, if used, the force necessary to overcome the inertia of moving parts consume a further portion of power. Of these components, which are over and above that power which is expended in the lamps and motors, those which magnetise the field, and overcome the friction of bearings and the inertia of moving parts, remain about the same whether one lamp or a thousand are in operation. This is considering the kind of machine I think necessary in a system of general distribution in which this extra work should be chargeable to a large number of lamps.

Consideration of the above and some other points, which will be obvious on mention, lead me to the following conclusions.

1. The resistance of the armature of the generator should be as low as possible compatible with the power necessary to furnish the required electromotive force.

2. The generator should be able to produce this electromotive force with the field magnets at less than the maximum economic saturation, and at a velocity less than that at which the armature can be safely run, in order that there may be a margin for increased efficiency in case of an unexpected demand.

3. The lamps and motors should have a high resistance, the standard lamp not higher than 475 to 500 ohms.

4. The resistance of the conductors should be as low as practicable, and should be graded in size for the current required.

5. The electromotive force of the generator should never rise to over 170 volts.

6. The lamps should be simple of construction, durable and cheap, and all alike.

7. The generator and the engine should be of the most substantial construction.

8. The points of derivation should all have, and all be maintained at, the same difference of potential as nearly as possible.

9. The energy necessarily lost in the armature and conductors of any fixed resistance for lamps of the same absolute economy varies inversely as the resistance of the lamps, or as the square of the current used.

10. Since in a single generator the total power used is not proportional to the number of lamps in circuit, a machine should be run nearly to its maximum capacity.

11. There should not be a single generator or a single circuit which may be destroyed, but such an arrangement that the external demands, both with regard to resistance and current required, may be met by suitable changes in the resistance and supply of the generative system.

12. The relation of internal and external resistance should be the same in a system as exists in a single generator when worked to nearly its full capacity.

13. With such proper relations of internal and external resistance the electromotive force will vary but slightly, and the power used will be very nearly proportional to the number of lamps or the current developed.

14. Insulation of conductors and of the armature should be good, and provision made to prevent fire arising from an abnormal increase of current.

15. Means should exist of accurately measuring the current used.

16. A large system should be as economical as a single generator worked nearly to its full capacity, and should be capable of regulation with the same ease.

Much has been said about the sub-division of the electric light and the current, and such sub-division of electricity has been the great bugbear in the distribution of power and light through its medium. This term, while conveying an idea, is in reality essentially wrong. It implies the existence of a current, the expenditure of energy, before the required sub-division of such current is made. We do not wish to sub-divide a current; a current which must be divided before it can be used is not a desirable current.

If we had a reservoir of water dammed up to a certain height, and tap it at the depth, say, of 20 ft., a stream of water will issue proportional to the depth of water and the size of the orifice, and the amount of water flowing in a unit of time will be constant if the height of the water above the outlet be kept the same. By damming up the water we have established a certain potential, but there is no flow of water, no current, and consequently no supply until the orifice is made. Such orifice, aided by the potential of the water, in itself establishes a flow, creates the necessity for a supply. If we make another, a larger outlet, a larger amount of water will issue, and the amount in the first will not be changed if the height of the water remain constant. By opening this second channel we created an additional current, the necessity for a further supply, but such necessity, such flow did not

exist until the creation of the new demand. Our reservoir may be large, our source of supply may be great, but if a sufficient number of openings be made, both reservoir and supply will be fully used, and while expensive for a single channel will be economical for the whole.

So it is in the distribution of electricity. A current is a function not alone of potential, but of potential and resistance. We desire to establish a certain potential, or difference of potentials, and to maintain this so that when a circuit is established, a channel opened, a current may be established in that circuit. We do not divide a current, nor a potential, but having established a difference of potential in two conductors, we open one or more paths, and a current flows over these paths dependent on their resistance, and independent of each other, and such additional current having been formed, the current over the main conductor is increased by just such increment, which increment did not exist until the new path was made. There has been no sub-division of a current: there has been a creation. Such new current having been made, of course more power must be supplied to maintain the existing potential, and while the system may be expensive for a single lamp or motor, when the number of derived circuits becomes sufficiently numerous, it will only be what is required for an economic and efficient supply.

I will now consider the Edison system in the light of the foregoing conclusions. (See page 172.)

CRITICISM OF THE EDISON SYSTEM.

(*Continued from page* 174.)

In the discussion which followed the reading of this paper, Prof. S. Thompson said that while the paper just read embodied a very extensive amount of details and of principles known to electricians, he must say that he was astonished to hear it stated that there was a scientific prejudice against large dynamo machines. He had never met with it, and he believed that the feeling was all the other way. He also did not quite understand what Mr. Sprague meant by "magnets of greater projective powers." The expression was new to him.

Mr. Sprague stated that he simply meant the field power of the magnets.

Mr. Swan rose to express his pleasure at having received such a very full and excellent description of distribution in every detail. He did not feel disposed to take exception to the general principles laid down as to the mode of effecting that distribution. It was certainly done in the simplest way by connecting lamps in arc system. They were certainly now subject to the limitations as to a distance, so distinctly pointed out by Mr. Sprague; but we might emphasise the conditions of such distribution by showing that the difficulties would be lessened by making the filament as fine as possible, so as to obtain the utmost resistance consistent with, say, a 10-candle limit. But when that resistance had been obtained by diminishing the diameter and increasing the length—the light remaining constant—there was still a resistance in the lamp (?) which limited the extent to which distribution might be carried to a lamentably small area—a mile, or something like that. This was a regrettable limitation, but he saw no escape from it with the construction of the lamp. They had a fixed material—carbon—to deal with; they could not alter its specific resistance much, so that they were very much restricted in the extent of their distribution. The only escape from that limitation lay in having secondary batteries at stations or in every house, and in these batteries being connected in series and fed by currents of a higher tension; the principle still holding of multiple arc not from the central station, but from the subsidiary one at which the batteries are charged. Once imagine the possibility of these secondary batteries being maintained at a perfectly constant condition of charge by some automatic arrangement, and we might look to that as a means of escaping from the difficulties of wide distribution. It would only require that each lamp should be provided with an automatic arrangement for maintaining continuity of circuit. Such might be of an exceedingly simple character without adding much to the expense of the lamp. It might be a permanent thing, not to be renewed as often as the lamp, and under such conditions one saw no limit, supposing the lamps could be fed in series to the extent to which distribution might be extended. The only conditions necessary would be the maintenance of the lamps in a condition of equality of light, that the current should be kept constant, and that there should be automatic arrangements for varying the electromotive force at the station in proportion to the number of lights operating, whether one or 1,000. To avoid the use of a very high potential in such a system of feeding in series, the resistance might be very considerably reduced by variation of the internal sectional area of the carbon by using short and flat carbons. He might simply mention the alternative method as a comment upon Mr. Sprague's very positive assertion that they were shut in to the one system of feeding the lamps in multiple arc. He was perfectly ready to allow that that method was the only one in use, except to a very limited extent; but still they must not lose sight of the power of wider distribution which they should obtain by either the entire series feeding of lamps or the use of the series method, with the charging of secondary batteries and there feeding from multiple arc. He felt it was very desirable that they should, by some means or other, see their way to a wider extension, even with all the conditions of low resistance in the armature, which Edison had carried to an extraordinary degree, and high resistance of the carbon. They still had a limited area of distribution, with undue cost. With regard to the dynamos, it was quite an error to say that there was any prejudice as to large dynamos. He had been delighted to see the success of Mr. Edison's efforts in the construction of large dynamos. Mr. Sprague had referred to the use of a shunt current, when less than the whole number of lamps were lighted. It was evident that the same current would pass through the shunt whether few or many lamps were lighted, and evidently the loss would be somewhat greater when only a few lamps were being operated. Reference, too, had been made to the limit to the use of high resistance in the carbon, consequent upon the limit constituted by the tendency of the discharge to take place between the terminals, when there was a great difference of potential between them. That was a difficulty which was to a very considerable extent met by removing the terminals to a great distance, and he did not think that that would be found to constitute a very serious obstacle in the way of an extension of the system.

CORRESPONDENCE.

TO CORRESPONDENTS.

No notice can be taken of anonymous communications. Whatever is intended for insertion must be authenticated by the name and address of the writer, not necessarily for publication, but as a guarantee of good faith.

Correspondence should arrive not later than Tuesday morning if it is desired to appear in the following number.

S. A. VARLEY'S CARBON LIGHTNING PROTECTORS.

To the Editors of THE ELECTRICAL REVIEW.

SIRS,—I think it might interest some of your readers to know that I have had 110 of S. A. Varley's carbon lightning protectors (which are referred to in the leading article of the ELECTRICAL REVIEW of the 19th instant) in use in connection with Tyer's train signalling instruments for many years, and that I have not had a case where lightning has damaged an instrument to which a carbon protector is connected.

Seventy-three of these protectors were put in use in February, 1867, and thirty-seven in March, 1872.

I am, Sirs,

Yours faithfully,

F. T. J. HAYNES,

Telegraph Engineer and Superintendent,

B. and E. Division, G.W.R.

Taunton, *August 26th*, 1882.

MAGNETIC UNITS.

To the Editors of THE ELECTRICAL REVIEW.

SIRS,—As a paragraph in your paper for August 26th, p. 156, headed "Magnetic Units," might possibly lead a casual observer to think that the idea of my instrument was taken from Prof. Silvanus Thompson, in order to show that this is not the case, I wish to quote a few lines from a very kind letter to me from Prof. Thompson. They run thus: "And it will give me much pleasure whenever I do publish an account of my instrument to mention that the same idea occurred independently to you. I have not used the mirror arrangement in connection with my instrument, so that application is exclusively yours."

These few words will, I think, quite do away with what otherwise might introduce an error.

Yours faithfully,

FREDERICK JOHN SMITH.

Taunton, *August 26th*, 1882.

THE TELEPHONE.

To the Editors of THE ELECTRICAL REVIEW.

SIRS,—Your correspondent "Injustice" says I have "a little more of *law* than of *justice* in my composition." He admits, then, that I have both law and justice in my composition; and I am well pleased with his admission, especially as the statement which I laid down with an "airy authority" is simply a repetition of the decision rendered by Mr. Justice Fry on the law, "that any transmitter combining a diaphragm with a tension-regulator is clearly an infringement of Edison's patent."

The remarks of "Injustice" in regard to Anders' transmitter seem to me to show, on his part, a want of knowledge of the English language, and of its phraseology. My assertion was, "that *any* transmitter combining a diaphragm with a tension-regulator is an infringement of Edison's." I did

not mean to assert that any of the parties named had made a transmitter; but if they or the man in the moon had made a transmitter "combining a diaphragm with a tension-regulator," such a transmitter is an infringement of Edison's, as decided by Mr. Justice Fry and Lord M'Laren. I fail to see the justice of "Injustice" in introducing the Reis transmitter of 1861 into his reply to me, because I made no reference to Reis's instrument. His object, however, is obvious—namely, to ventilate his *opinion* obout the Reis transmitter as being different from the opinions expressed by Sir Frederick Bramwell and other witnesses before Mr. Justice Fry in regard to the Reis transmitter, which, Sir Frederick said, "did not act as a tension-regulator."

Every one has a right to have an opinion on any subject, although he may enjoy a blissful ignorance of that subject.

There seems to me to be a wide difference between the importance to be attached to an opinion, and that to the solemn judgment of the High Court of Justice.

In my letter I did not express any *opinion*. I now merely recite the words of the decision of Mr. Justice Fry, who did not think it had been established "that Reis's transmitter combined a diaphragm with a tension-regulator."

I confess that I have a very clear opinion on this matter, but I will not presume to ventilate it in the face of Mr. Justice Fry's decision; but I do express a strong desire that the question will be taken before a higher and the highest court, so that it may be finally settled whether Reis's transmitter of 1861 is an infringement of Edison's of 1877. Perhaps "Injustice" may have embraced the opportunity to pay a *well-merited compliment!!!* to the great patentee of patents with hundreds of specific claims for old well-known devices.

JUSTICE.

To the Editors of THE ELECTRICAL REVIEW.

SIRS,—With due deference to the "editorial chair" I take leave to say that there is criticism and hypercriticism. To this latter it seems to me that your remark upon my using the words "inductive action" belongs. It must have been evident to you that I quoted these words from Bell's specification, as also from the evidence given by the eminent electrician, Sir Frederick Bramwell, and also that it was necessary for me to use those words to elucidate in a clear manner the claim of Bell, in contradistinction to my claim, and I thereby did not "erroneously consider" "inductive action" to be synonymous with "induction." Inasmuch as eminent electricians and a learned judge have used the term "inductive action," would it be amiss for you to clearly define the distinction between "inductive action" and "induction" for their benefit?

Yours as ever,

W. C. BARNEY.

53, Bernard Street, Russell Square,
August 29th, 1882.

[We were, perhaps, a little unfortunate in attributing to Mr. Barney the words made use of, also in our use of the term "induction," "*direct* inductive action" would, perhaps, have better explained what we meant. The movement of the plate in Mr. Preece's telephonic receiver is certainly caused by "inductive action," although the action is not *direct*. "Inductive action" we take to mean "an action caused by inductive effort." When we speak of the wheel in a steam engine being moved by the action of the piston, we do not mean that there are no cranks or connecting rods between the two. The material of a diaphragm or disc may not in itself be capable of *direct* inductive action, but may be actuated indirectly by inductive action.—EDS. ELEC. REV.]

CITY AND GUILDS OF LONDON INSTITUTE TECHNOLOGICAL EXAMINATIONS, 1882.

To the Editors of THE ELECTRICAL REVIEW.

SIRS,—It is with reluctance that I again ask a portion of your space to continue a discussion already outside the range of utility; but there are one or two points which I should like to notice before it is closed.

I would thank "The Student" for his testimony to the value of a theoretical and practical training. I did not for one moment suppose that his knowledge was "examinational," because three years ago I made myself acquainted with the admirable teaching at Cowper Street, and I have no doubt had he been subjected to a *practical* examination his position would have been equally distinguished.

"A. C. S." suggests that my friend's abilities are microscopic. They certainly are not. He is intelligent, familiar with principles which underlie the Duplex, Quadruplex, and other systems of telegraphy, and has on many occasions ably assisted his fellows in their telegraphic studies. He gained a first advanced prize for electricity and magnetism, and has read a good deal. My other friend knows little of mathematics and less of dynamics, and his chemical knowledge has been gained from Preece and Sivewright's "Handbook of Telegraphy."

"Maga" is right when he says there is a great temptation to try for the highest place at once. Our hours are irregular, and we can but ill spare time and money on a study so lightly valued. Our opportunities of acquiring a thorough knowledge are prescribed, as we are prohibited from examining the apparatus we work; there are but few amongst ourselves able and willing to teach "the young idea how to shoot," and when such an one appears for a little are we to be blamed for attempting to reach the goal at a bound? From our superiors we receive, instead of the smile of approbation, the frown of disapproval, and when two or three of us combine for mutual assistance obstacles are put in the way of our meeting. Let the heads of our department announce unequivocally that they desire and will recognise technical knowledge, and for every one who now attends the classes of the Guilds there will be a dozen. "Maga" says, "the questions set for the May examination were specially directed against 'cram,' and no student who had not combined a practical with a theoretical study of the subject could have answered them satisfactorily." For example:—

"Point out the difference between conduction and induction across air in a thunderstorm?"

"To whom are we indebted for the introduction of telegraphy into practical use, and when?"

"Describe the modern system of electrical measurement and detail the different units in use?"

"Describe Bell's telephone and show how speech is reproduced at a distance by its agency?"

Verbum sat sapienti!

This gentleman says, "Your correspondent goes on to state that such a course (theoretical and practical) cannot be gone through at the City and Guilds classes." If he will refer to my letter he will find I did nothing of the kind. I asked "if students more ambitious to win prizes than gain genuine knowledge, and teachers more anxious to increase their incomes than impart lasting instruction, would give to practice the attention it deserves."

The cry of "Aba" about calling in question the quality of his own or *protégé's* knowledge can be appreciated when we know that the particulars of the case cited by me "tally exactly" with those known to him.

Qui se seut galeux se gale!

Nothing has been advanced against my plea for a practical examination to go along with the written one. I believe the day is not far distant when steps will be taken by the City and Guilds Institute to test the progress in practice of those attending their classes, and so still further promote the usefulness of the work they have so well begun.

Yours truly,

FAREHAM.

THE PILSEN-JOEL AND GENERAL ELECTRIC LIGHT COMPANY, LIMITED.

To the Editors of THE ELECTRICAL REVIEW.

SIRS,—Your somewhat unfavourable notice of the Pilsen-Joel and General Electric Light Company, Limited, which appears in your current issue, has evidently been written without previous inquiry. I have had the pleasure of showing you over the company's factories since your notice was written, and I think you will admit that considerable progress has been made in the short time that has elapsed since the company was formed, and also that the engineering portion of the company's work is satisfactory.

I have pleasure in informing you that the new accumulator, obtained by myself for the company, promises to be a great success; and when the very large prices that other

companies have paid for accumulators, and the merely nominal price asked by my co-patentee (I having given my share to the company), I think you will also admit the company's prospects are in every way favourable.

I will conclude by reminding you of the many notices of orders and work in hand you have from time to time published in your journal; in the number in which your criticism appears two fresh orders are noticed.

I am, Gentlemen,
Your obedient servant,
HENRY F. JOEL.

August 27th, 1882.

[In reply to our correspondent's letter, which we are pleased to insert, we assure him that our "note" was *not* written without previous inquiry and due consideration. We derived considerable satisfaction from our visit to the Pilsen factories, and can congratulate Mr. Joel on the energetic manner in which the various departments have, under his direction, been planned and fitted up. As far as the factory is concerned no fault can be found, it being a subject rather for praise. We cannot see that the addition of the new accumulator mentioned by our correspondent can affect the prospects of the company in either direction. It would appear that this fresh acquirement is either of little value, or that Mr. Joel has been exceedingly generous. However, engineering work and commercial ability are not synonymous terms. In respect to the latter portion of his letter we will ask: Is it true that Messrs Brindley and Co. have countermanded their orders, or that Messrs. Crisp, of Holloway, have intimated their desire to have the Pilsen-Joel Company's system removed? Is the company in a position to do its own work, or does an intermediate firm influence the company's operations? Perhaps one of the directors could enlighten us on this point. How is it that various concessions have fallen through? For what reasons did the assistant-engineer of the company resign his engagement over the Liverpool installation, and is it a fact that their energetic commercial representative has tendered his resignation? We consider we were quite justified in our "note" on the subject to which our correspondent alludes. In conclusion we may add that we still hold the most favourable opinions as to the merits of the Pilsen-Joel Company's system, and we shall be very pleased to make public any refutation of what we have written if Mr. Joel can show where we have been mistaken.—EDS. ELEC. REV.]

ELECTRIC LIGHT TENDERS.

To the Editors of THE ELECTRICAL REVIEW.

DEAR SIRS,—I feel extremely reluctant to trespass upon your valuable space on a personal matter, but as Mr. James Beattie calls my veracity into question in your last issue, I feel certain that you will do me the kindness to publish my reply.

Mr. Beattie intimates that I publicly made a false statement, knowing the same to be untrue, and it pains me to know that there is a gentleman engaged in the same electrical work as myself who thinks me capable of such a dishonourable course.

Those of your subscribers who read his letter will be interested to know that I emphatically repeat "that the one tender sent in to the Camberwell Vestry was that sent by the Metropolitan Brush Company." Of course I refer to the most recent invitation of the Vestry for electric light tenders on the revised specification as recommended by the committee. Of this invitation Mr. Beattie seems to have been ignorant, and to have left us in possession of the field, though on the first invitation I find that the two tenders sent in were from the Pilsen-Joel and Metropolitan Brush Companies respectively, but a glance at the minutes of the Camberwell Vestry meeting will show Mr. Beattie that "*the one tender*" referred to by Mr. Price at the Metropolitan meeting, in the discussion and in the public prints, was the one from the Metropolitan Brush Company. The two earlier tenders, one from us and one it appears from the Pilsen Company, were treated as entirely out of court.

Yours faithfully,
R. HAMMOND.

110, Cannon Street, *August 30th*, 1882.

IMPROVEMENTS IN ACCUMULATORS.

[IN our issue of July 29th we took exception to the methods adopted by M. Blanchart in obtaining the results of his tests on electrical accumulators. On the 19th ult. we published a long and interesting letter from that gentleman, to which we now take the opportunity of replying.

To evade a question is not to solve it. It is not a matter of ascertaining whether the capacity of accumulators of equal weight may be increased. No one doubts that. Our *critiques* published in the ELECTRICAL REVIEW of the 29th of July, page 71, only aimed at the method of calculation adopted by M. C. Blanchart, and the facility with which one obtains surprising figures when the art of using them skilfully is acquired. M. Blanchart's letter answers absolutely nothing to these *critiques*. He does not dispute, in fact, that his calculations relative to kilogrammes of *active matter* only take into account the weight of the oxidised plate, and ignore altogether that of the reduced plate, the liquid, and the receptacle. It is, indeed, a convenient mode of obtaining high figures, but it is impossible for us to accept it, for, we repeat, the reduced plate is also active matter, and the idea of ignoring its weight has never occurred until now to any experimentalist.

M. Blanchart protests on the ground that we make him *say* that the electromotive force is constant, which, according to him, is not true. We beg M. Blanchart's pardon, but he has plainly *said* it, and *written* it, adopting in his calculation the formula: $\text{Tr.} = \frac{\text{E I}}{q}$, and taking for E the constant value of 2·15 volts. Was M. Blanchart authorised by previous experiments to take the figure of 2·15 volts as a constant electromotive force? The rapid decrease of a discharge current shows that it is not so and, moreover, the experiments of MM. Joubert, Pothier, and Tresca, have shown a diminution of from 2·165 volts to 2·057 volts, whilst the intensity of the current fell from 16·37 to 11·49 ampères. MM. Gladstone and Tribe have demonstrated also that after thirty minutes of rest or discharge the electromotive force which, in a *freshly charged* battery, is from 2·21 to 2·31 volts, falls to 2 volts, and even to 1·92 volts after forty-five minutes. Are these experiments sufficient to authorise M. Blanchart to accept in his formula a *constant* electromotive force of 2·15 volts?

As to the figures given by M. G. Planté, M. Blanchart neglects to state—what is essential, nevertheless—that if the battery has an electromotive force of from 1·45 to 1·50 Bunsen immediately after the discharge, if this electromotive force be measured *two or three minutes after the interruption of the primary current* (*see* the "Recherches sur l'Electricité," by M. Gaston Planté, p. 75) it is not more than 1·17 Bunsen.

We hold besides, with M. Planté himself, that we cannot count upon an electromotive force higher than 2 volts when the battery is *discharging*.

In conclusion, we maintain absolutely in meaning as in word our *critiques* upon the very original mode of calculation adopted by M. Blanchart, being unable to accept the hypothesis of a *constant* electromotive force in the case of a gradually *decreasing* discharge, and a calculation which, in the attempt to bring forward high results, takes into account as *active matter* only the oxide of lead.—EDS. ELEC. REV.]

THE TELEPHONE.—The United Telephone Company have opened an exchange at Brighton, and active operations have begun. Arrangements for connecting that town with the metropolis, under the powers granted by the Post-office, are now being made.

From Aberdeen we learn that there has been during the past few weeks a great increase in the number of subscribers to the exchange of the National Telephone Company. The desirability of putting the various fire-engine stations in telephone communication with the exchange, is now under the consideration of the fire committee, and should they report favourably arrangements will probably be made for keeping the exchange open always.

From Dundee we receive equally gratifying reports: the Dundee and District Company, and the National Telephone Company, are said to be working hard and adding many subscribers to their exchanges.

NOTES.

EXTENSION OF ELECTRIC RAILWAYS.—A *Post* telegram from Berlin, dated 22nd August, says :—"There is a great increase in the construction of electric railways throughout Germany, their success being established."

THE STEAMSHIP "INTERNATIONAL."—The s.s. *International*, belonging to the India-Rubber, Gutta-Percha, and Telegraph Works Company, returned on Sunday morning, the 27th ult., from Mexico and the West Indies, where she has been engaged in the extension of the Tampico-Brazos Santiago cable to Galveston and afterwards in the repairs of one of the International Ocean Telegraph Company's cables from Key West to Habana.

Both these undertakings were successfully carried out by Mr. Theophilus Smith, engineer-in-charge, assisted by Mr. H. Benest, Mr. J. Rymer Jones, Captain W. F. Wardroper, and others. The repairs of the Key West-Habana cable, however, were effected under the supervision and direction of Mr. M. L. Hellings, cable manager at Key West.

When the *International* has discharged her ballast and docked, she will receive the cable which is now being made at the Silvertown Telegraph Works for the French Government, to be laid along the coast of Tunis, from Soussa to Sphax and from Sphax to Gabes.

THE KEY WEST-HABANA CABLE.—We understand that the Key West-Habana cable of the International Ocean Telegraph Company of New York, which was repaired on July 15th last, had broken down again on the 22nd ult., and that the s.s. *Duchess of Marlborough*, one of the repairing vesse'ls of the West India and Panama Telegraph Company, has been chartered for the purpose.

THE FRENCH ATLANTIC CABLE.—The *Times* says, "On the morning of the 29th ult. the Telegraph Construction and Maintenance Company's steamer *Scotia*, engaged in repairing the French Atlantic cable, put back into Plymouth from the Atlantic the second time in two months. When in May last the *Scotia* left London she had on board some 4,000 tons of cable stored in her immense fore and aft tanks. About 1,000 miles from Brest the cable was connected, and the vessel returned to within 400 miles of Brest to make good "a fault." Upon this work being taken in hand it was found that the American end of the cable was again broken, and testing demonstrated that the accident had occurred 20 miles east of the original breakdown. Buoying the cable, the *Scotia* came on to Plymouth, shipped coals and provisions, and left. The cable off Brest was spliced, and the *Scotia* sought the new fault. This was discovered, but considerable trouble was experienced in the endeavours to repair it. The cable was several times chafed at the bottom and parted, with the result that, after a month's work, affairs remain practically as before. One end is now buoyed ; the other is at the bed of the sea. During the operations 140 miles of cable have been paid out."

FURTHER EXTENSION OF THE NETWORK OF FRENCH CABLES ALONG THE NORTH COAST OF AFRICA.—In our number of the 5th ult. we stated that the India-Rubber, Gutta-Percha, and Telegraph Works Company had contracted with the French Government for the making and laying of 260 nautical miles of submarine cables to connect Soussa with Sphax and Sphax with Gabes. We are now informed that the same company has received a further order for cables to be laid from Gabes to a point on the west coast of the island of Djerba.

The making, &c., of these cables is superintended at the Silvertown Works, on behalf of the French Government, by Messrs. Rambaud and Schaeffer, engineers in the French Telegraph Administration.

Djerba, or Jerbah, is a large level island lying S. by W. $\frac{1}{4}$ W., forty-three miles from Gzira, the western island of the Kerkenah group ; it is about nineteen miles in length east and west, and eighteen north and south, irregular in outline, especially on the southern side, and comprising a coast-line of about eighty-five miles in circumference.

The island is very fertile, with thick plantations of date and olive trees ; upon the coast are several forts ; villages and neat-looking white cottages are scattered over the country. There is a considerable trade in oil, wool, and fruit. Shawls, &c., are manufactured and exported, and there is also a large pottery. The island still produces the lotus, from which it derived one of its ancient names "Lotophaji."

The principal town is Zoug, which has a castle and the singular pyramid of skulls commemorating the defeat by the Turks of some Spanish soldiers under the famous Andrea Doria.

THE ELECTRIC LIGHT.—At the annual three days floral *fête*, which opened in Dundee on Thursday last, the Northern Light Company exhibit one of their systems of electric lighting. At a meeting of the Aberdeen Market Company, held on Friday week, to sign the contract for the restoration of the building which was recently destroyed by fire, it was intimated that the propriety of lighting the new building by electricity was engaging the attention of the directors.

The Highland Railway Company are at present considering proposals from several electric appliance companies to light the Inverness Station, the Station Hotel, the offices, and the company's works by electricity. At a meeting convened by the Ratepayers' Association of Gainsborough, to approve or disapprove of the adoption of the electric light as a street illuminant by the Board of Health, a resolution, "That this meeting, having had an opportunity of judging the capabilities of the electric light and contrasting it with gas, urgently recommend the Local Board of Health to adopt the electric light for lighting the town, if the cost compares favourably with the price paid for gas," was carried *nem. con.* amid loud applause.

On Saturday evening last, the additional lamps, which have been fitted up at the Waverley Railway Station, Edinburgh, were brought into use. So far the light has given the greatest satisfaction and compares advantageously with the experiments conducted twelve months ago on Princes Street. We believe that an application is about to be made to the Town Council for permission to make another series of experiments with the light on the streets.

THE ELECTRIC LIGHT AT COLCHESTER.—Information has reached us that the S. E. Brush Electric Light Company has established a station at Colchester. Owing, however, to some alteration in the driving apparatus being necessary some delay has occurred in bringing the electric light into use at Messrs. E. S. Sanders and Son's establishment, but it is confidently expected to be in operation before the end of the present week. The station is for the supply of the Brush system, and several of the leading firms in the town have expressed their readiness to adopt the electric light as soon as the station is in working order.

THE ELECTRIC LIGHT FOR SNARING FISH.—In our issue of July 15th we published a letter from "DENSHIN" suggesting the use of the electric light for attracting fish towards the nets. From France we now learn that in the hands of some ingenious Frenchmen, who have lately, by permission of their Government, been experimenting with it, the results obtained have been highly satisfactory. The lamp was contained in an air-tight globe, and was lowered at night into the sea, with the result that thousands of fish of all sizes were attracted to its brilliant light. Boats furnished with nets gradually closed in upon the living mass and made a great haul of fish.

THE JABLOCHKOFF ELECTRIC LIGHT.—Messrs. Shoolbred and Co., of Tottenham Court Road, have now forty lamps in use in their various departments. We understand that Messrs. Shoolbred are satisfied with the financial results.

THE ELECTRIC LIGHTING IN THE BIRMINGHAM TOWN HALL.—Swan incandescent lamps are employed to the number of 496, the electric current being furnished by Bürgin dynamo machines, stationed at the Cambridge Street Works, and connected with the hall by cables laid under-

ground. The greater number of the lamps are arranged on pendant brackets attached to the pilasters which form the leading feature of the structural decoration of the hall, and there are also fifty-two lamps placed in pairs underneath the galleries. These brackets, which are of brass, have a bold, curving sweep outwards and downwards, and then divide into twelve branches. To each branch is attached a small Swan lamp. Along each side of the hall are eight of these brackets, each bearing a cluster of twelve lamps. Over the orchestra there are six double brackets, carrying twenty-four lamps each, while four similar brackets overhang the great gallery. The light thus provided is estimated to be equal to 8,000 candles, as compared with 5,600, which is the power of the ordinary gas illumination of the hall. An engine of 120 horse-power is employed for driving the dynamo-electric machines, there being twelve "Bürgins" of the C type, three being used as excitors for the remainder. We understand that the copper conductor of the cables was manufactured by Messrs. Winfield & Co., of the Cambridge Street Works, and the covering was done by Messrs. Glover, of Manchester. We believe hopes are expressed that the installation may be for a permanency.

THE TELEPHONE IN THE DIVING BELL.—On the suggestion of Mr. H. H. Wake, the engineer to the River Wear Commissioners, says the *Newcastle Chronicle*, the telephone has been applied as a means of signalling between the workmen in the Commissioners' diving bell and the workmen in charge of the crane and air-pump for governing the bell, in the craft employed for submarine work. On Saturday last Mr. A. W. Heaviside, the superintending engineer of the Post-office telegraph system, and Mr. H. H. Wake, made a successful trial at the entrance to the South Dock, Sunderland. The signalling between William Cooper in charge of the diving bell at the bottom of the river and James Miller in charge of the machinery in the craft at the surface was all that could be desired. In fact, everything that proceeds within the bell can be heard above, every stroke of the hammer or whisper of the men. So far as is known, this is the first occasion on which the telephone has been applied to so useful a purpose. It is worthy of remark that in this application of the telephone, which will be exhibited at the forthcoming North-East Coast Marine Exhibition, to be held at the Tynemouth Aquarium, the workmen in the bell have no necessity to speak into the telephone whatever. So long as the telephone is within the bell it records all that is passing."

This is, as our readers are aware, not the first occasion on which the telephone has been applied to the diving bell. In March, 1880 (vide ELECTRICAL REVIEW, Vol. viii., page 125), an experiment similar to the above was made at the Earl Grey Dock, Dundee.

WAR AND SCIENCE.—The Oriental Telephone Company have received from their representative at Alexandria an extract from an official letter to the Admiralty from Admiral Sir Beauchamp Seymour, who writes as follows:—"The telephonic communication which I reported in my previous letter had been established between the *Helicon* and the British Consulate has proved of the utmost value to me since the outbreak of this *émeute*, and inspired the English residents with a certain amount of confidence, as by its means I have been kept constantly aware of the state of affairs generally. In default of this ready means of communication it would have been impossible for some hours to have gained any information from the town except by special messengers, at imminent risk of life."

AN UNPRODUCTIVE TELEGRAPH OFFICE.—Fully twelve months ago, a Postal Telegraph Office was opened at the town of Keiss (Caithness), under a guarantee of £49. We understand that the receipts for telegraph business for the year amounted to the small sum of £24 9s., and consequently the two guarantors have received invitations to jointly contribute £24 11s., that the revenue may sustain no loss.

THE INTERNATIONAL METEOROLOGICAL COMMITTEE.—At the second meeting of this committee, recently held at Copenhagen, it was resolved to organise an exhibition in connection with the International Fisheries Exhibition, London, of the methods and apparatus used in different countries for giving weather intelligence and storm warnings to the coasts, and of the instruments, &c., used in the study of ocean meteorology. Several resolutions were passed with a view of obtaining greater punctuality and accuracy in the scientific information furnished to the committee. M. Tietjens, chairman of the Great Northern Telegraph Company, submitted a plan for a cable to connect Iceland and the Faroes with Europe, the expense to be met by the receipts from Meteorological telegrams. The committee, while re-recognising the very great importance which information got from Iceland and the Faroes must possess in relation to the issue of storm warnings and forecasts in Europe, felt they were not in a position to express an opinion on the practical execution of the project.

ON THE THEORY OF THE VOLTAIC BATTERY.—By G. Cantoni.—The author observes, in the first place, that the proposition of the co-existence of several movements can be used as the foundation of the reciprocal magnetic and electric inductions. He remarks, however, that if we regard bodies as composed of bipolar elements, each of which exerts two equal and opposite inductions, and if we contemplate a series of n such elements, the action upon the poles of each element of the series will be derived from the joint action of the poles, and of that induced by the homologous poles of the other elements. If m expresses the order of an element, p, of the series, the sum of the internal inducing actions of its poles will be $m + n - (m - 1)$; where the effects, m, have an opposite sign to those, $n - (m - 1)$; further, if p' is the element as far remote from the central position as p, the sum of the internal inducing actions of its poles will also be $m + n - (m - 1)$, where likewise the actions, m, are of opposite signs from $n - (m - 1)$. For the element, p', the effects, n, and $n - (m - 1)$, are of opposite signs to the effects, m, and $m - (m - 1)$, of the element, p. The algebraic sum of the inductive actions of each pair of elements, equidistant from the middle point of the series is, therefore, $= 0$; the action of the n elements of the series is also null; and that of the central element, or the central pair of elements, is null; whence follows the neutral line of the system. Since further, $m + n - (m - 1) = n + 1$, and is, therefore, independent of m, the sum of the inducing effects is constant for each element of the series.

If we approach to one pole, b, of an insulated electric element, a, b, an inducing ball, a', connected with the ground at a very small distance, and in a perfectly insulating medium, the end, a, of the ball displays, in consequence of the induced action of b, an equal and opposite inducing action upon b, so that the outward action of the other pole, a, is doubled. This corresponds to the impulse experiments performed with a series of balls of equal mass suspended in succession. Quite analogous is the composition of the inducing actions in coated insulators.

The author further compares such an insulator with a battery, and remarks, that if in the former the two poles are several times connected by a conductor, we obtain a series of discharges of decreasing intensity; whilst in a battery all the sparks are equally strong, since the heat evolved in the battery by chemical activity affords a constant source of energy. The succession of sparks represents the current.

Further observations refer to the fact that the current does not increase infinitely in a battery.

The author further discusses the thermic, chemical, and electrical phenomena which appear in a voltaic battery, amidst the reciprocal action of heterogeneous solids and liquids, whereby the intimate relations between the quantities of heat contained in the bodies, their combining weights and combination heat, but which do not appear in the open battery.

The author finally remarks, that Ohm's formula treats of the cause of the production of the electromotive force, whilst Faraday's and Joule's laws present equivalences between the values which appear in the current. He therefore considers the latter more essential than the former.—*Wiedemann's Beiblätter.*

ON THE ELECTRICITY OF FLAME.—By Julius Elster and Hans Geitel.—Concerning the electricity of flame there

exists a great mass of researches which contradict each other in several respects, both as to the results and as to the views put forward by different authors on the cause of the electricity of flame. The origin of the electric difference may find its explanation in the following three causes:—The electricity of flame is determined by the combustion process as such (Pouillet, Hankel). It is caused by the flame behaving as an electrolyte to the metals introduced as electrodes (Matteucci). It depends on a thermo-electric difference of the electrodes.

The authors have come to the following experimental results:—

1. The longitudinal polarisation of the flame is only apparent, and is elicited by the unequal introduction of the wires which serve as electrodes.

2. The flame evinces in its transverse section a strong electric polarisation, and the electrode which is plunged into the stratum of air immediately enveloping the flame is always positive towards the electrode which enters the flame itself.

3. The electromotive force does not depend on the size of the flame.

4. The change of polarity of the flame may be produced by a suitable displacement of the electrodes.

5. The electromotive force of the flame depends on the nature of the metals employed as electrodes and on the nature of the gases consumed. It is especially strong if aluminium or magnesium is used as a conductive metal, and especially weak if the electrode in the air is coated with salts, *e.g.* chloride of potassium.

6. By employing electrodes of water and excluding all metals indubitable electric effects of flame may be also obtained, the electrode in the air being always positive to that in the flame.

7. Flames may be combined after the manner of galvanic elements, thus forming a "flame-battery."

The magnitude and kind of the electric excitement are independent of the size of the flame, but depend on the nature and the superficial condition of the electrodes, on the nature of the burning gases, and on the state of ignition of the electrodes. The authors infer that Hankel's theory is not in harmony with the facts, whilst the kinds of excitation assumed by Buff and Matteucci may be regarded as simultaneously determining the apparent electricity of flame.—*Annalen der Physik und Chemie.*

ON THE ACTION OF TENSION UPON THE ELECTRIC RESISTANCE OF COPPER AND BRASS WIRES.—The wires were stretched in a tin-plate cylinder, filled with water, 913 mm. in height and 192 mm. in diameter. The displacement of the marks on altering the tension could be observed through box-shaped expansions, closed with glass plates. The corresponding changes of resistance were measured by means of Jacobi's rheostats. The most careful observation was made on three brass wires taken from the same original piece, and drawn successively thinner and thinner. The wire contained 63·66 per cent. of copper, the rest being almost exclusively zinc. In order to find the change of the specific resistance, the co-efficient of elasticity, E, and the co-efficient of torsion, C, were determined in kilos., and thus $\mu = (E/2\,C)\,4 - 1$ was calculated. If σ is the experimentally determined proportion of the relative change of resistance to the relative change of length, $\sigma' = \sigma - (1 + 2\,\mu)$ represents the proportion of the change of the relative specific resistance to the relative change of length. In the three wires, with the respective thickness of 0·91, 0·79, 0·46 mm., the co-efficients of elasticity and torsion of which became successively smaller, and the absolute electric resistance became greater, the ratio σ'' of the change of relative specific resistance to the relative change of length, increased from 0·298 to 0·316 and 0·415. The mean value of $\sigma'' = 0{\cdot}342$.—*Mél. Phys. de St-Pétersbourg.*

ON SYSTEMS OF ELECTRIC RECIPIENTS CONSISTING OF CHAINS.—By A. Jedlik.—Barometer tubes closed at one end before the lamp, 66 c.m. in length and 10 to 12 in diameter, are filled to the height of 39 c.m. with fine iron filings, coated without with tin-foil opposite the filings, and the free service covered with shellac varnish. A copper wire plunging into the filings leads outwards. Several tubes are set in a glass cylinder, which is closed above and below, with hollow brass globes or tin capsules, the one in contact with the copper wires and the other with the tin-foil coatings. In this manner they are connected as a battery. The surface of this battery is relatively large; there is no fear of an over-stroke over the broad uncoated margin, and it takes up little room.

A number of such tube batteries may be placed together horizontally or perpendicularly upon insulating feet, and may be connected either laterally or in succession. A Lane's jar, connected with the coating, which discharges itself at a certain charge of the battery, prevents the perforation of the glass tubes.

With a cascade-battery of four such elements the striking distance, under favourable conditions, is 30 to 40 c.m., and is nearly proportionate to the number of the elements. Between two wires, cemented into a glass tube with sealing-wax, the spark travelled along the surface of the tube for 90 c.m., whilst its striking distance in the air, in the latter case, was only 18 c.m.—*Wiedemann's Beiblätter.*

IMPROVEMENTS IN ELECTRIC BATTERIES.—Conical vessels containing the funnel-shaped electrodes, and each having below a supporting block, are inserted in each other. If the elements are to contain two liquids they are separated by funnels of felt. For secondary batteries the vessels are formed of lead, their two surfaces serving respectively as positive and negative electrodes.—*Wiedemann's Beiblätter.*

GEISSLER'S TUBES WITH VAPOURS.—By K. Krajewitsch.—The same series of luminous phenomena which is observed in Geissler's tubes, by increasing rarefication of the air is perceived; also if the tube is filled with saturated watery vapour, and is then gradually cooled more and more in a freezing mixture. If mercurial vapour is used instead of watery vapour, the tube gives no discharge at common temperatures, but if it is heated stratification appears.—*Jour. Russ. Phys. Chem. Gesell.*

NEW PATENTS—1882.

4036. "Apparatus for winding coils of wire upon the armatures of dynamo-electrical machines, and for like purposes." W. B. ESPEUT. Dated August 23.

4044. "Telephone receiving apparatus." R. and M. THEILER. Dated August 23.

4045. "Warning or signalling apparatus, for the protection of property and other purposes." A. GLUCK and H. DIGGINS. Dated August 23.

4046. "Electric arc lamps, and mechanism for electric lighting." J. D. K. MACKENZIE. Dated August 23.

4049. "Commutator for dynamo or magneto-electric machines." H. R. LEWIS and W. C. SMYTHE. Dated August 23.

4065. "Electric lamps." C. S. SNELL. Dated August 24.

4073. "Electric bell and automatic alarm apparatus, and the applications thereof. P. M. JUSTICE. (Communicated by V. Vankeerberghen.) Dated August 25.

4079. "Secondary batteries for the accumulation of electricity and mode of constructing the same." L. H. M. SOMZÉE. Dated August 25.

4080. "Electric measuring, recording, and regulating apparatus." S. H. EMMENS. Dated August 25.

4084. "Arc electric lamps." P. R. ALLEN. Dated August 26.

4087. "Lighting of railway trains by electricity and apparatus to be used therefor." H. E. NEWTON. (Communicated by Société Universelle d'Electricité Tommasi.) Dated August 26.

4110. "Telephonic apparatus." G. L. ANDEES. Dated August 28.

4111. "Dynamo-electric machines." H. H. LAKE. (Communicated by S. F. Van Choate.) Dated August 28.

4127. "Electric controller and indicator for clocks and for other purposes." J. WRIGHT. Dated August 29.

4147. "Galvanic batteries." S. H. EMMENS. Dated August 30.

4148. "Generating, intensifying, and accumulating, or storing electrical energy." P. DE VILLIERS. Dated August 30.

4149. "Hanging electric and other lamps, and other articles, and for removing them from their place of suspension." A. M. CLARK. (Communicated by H. G. Fiske.) Dated August 30.

ABSTRACTS OF PUBLISHED SPECIFICATIONS.

1881.

5688. "Cymaphens or apparatus for transmitting sound by electricity." C. F. VARLEY and F. H. VARLEY. Dated December 27. 10d. The first part of the invention may be described as a diaphragm microphone. Fig. 1 represents one arrangement of this invention. On the end of the style, E, there is an adjusting nut for regulating the pressure spring, *b*, which is made to press the cross bar, *a*, against the contact pieces, *c*, c^1. To cross bar, *a*, an armature, *f*, made of

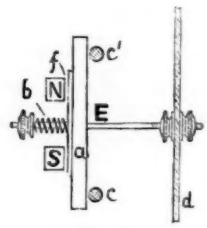


FIG. 1.

iron or other suitable magnetic metal is attached. Near to this armature the poles, N and S, of an adjustible magnet are placed; these poles attract the armature and counteract the force of the spring, *b*. It is obvious that if the magnet is of sufficient force, it would overcome the pressure of the spring, *b*, and open the circuit between *c* and c^1—if the space between armature, *f*, and the poles, N and S, be increased the magnetic force is weakened, and the spring, *b*, forces the cross bar, *a*, into contact with *c* and c^1,—thus by regulating the distance of the magnet *n. s.* and the force of the spring, *b*, any degree of contact pressure can be produced, and the most sensitive condition for transmitting sound by means of electric waves obtained. Fig. 2 shows a simple method of producing the augmentation of the variation of the current. To the diaphragm, D, is attached an iron crook, C, making contact with c^1, which latter is adjustible. The current

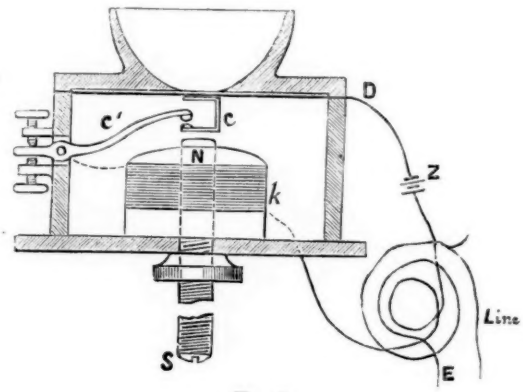


FIG. 2.

from the battery passes through C to C^1, thence through the coil, K, around the pole of the permanent magnet, N. S. When the diaphragm is pressed towards N. the contact pressure between C and C_1 is diminished. The current which passes around K reduces its magnetic power. When the pressure between C and C^1 is diminished, the current in K is diminished, and therefore the magnetism of N is increased, and thus the amplitude of the variation of the electric wave is augmented. It is obvious that if the current passing round K is too strong it will form a vibratory make and break.

1882.

130. "Machinery for obtaining, transmitting, and applying electric currents for lighting, &c." W. T. HENLEY. Dated January 10. 1s. 6d. Relates chiefly to dynamo machines similar in general construction to those described in the number of the Review for August 1st, 1881.

305. "Electric lamps." J. N. ARONSON. Dated January 21. 6d. An incandescence electric lamp, according to this invention, is constructed with a globe or translucent containing vessel having one or more reflectors formed in, on, or with the material of such globe or vessel itself. The reflective surface may be produced by silvering, painting, gilding, or enamelling the material of the globe or vessel either inside or out, or by shaping the globe or vessel so that it shall form one or more dioptric or cata-dioptric lenses or prisms.

346. "Electric lamps, &c." R. E. B. CROMPTON. Dated January 24. 8d. Relates to improvements in the inventor's well-known arc lamp.

358. "Sounding apparatus." C. A. McEVOY. Dated January 24. 2d. The improved sounding apparatus operates by completing an electric circuit when it comes into contact with the bottom. (*Provisional only.*)

CITY NOTES.

OLD BROAD STREET.

THE GÜLCHER ELECTRIC LIGHT AND POWER COMPANY (LIMITED).

ON Wednesday morning the first ordinary general meeting of the shareholders of the above-named company was held at the Cannon Street Hotel under the presidency of Mr. John Blundell, chairman of the company.

The secretary, Mr. C. B. Charlewood, having read the notice convening the meeting,

The Chairman said: Gentlemen, this you are aware is called the statutory meeting of the company held, by the requirements of the Act of Parliament, four months after the registration of the company, which took place on May 1st. It is not usual at such a meeting to go into detail or formal business, but we have simply now to tell you how far we have progressed with this company. You are aware that the company only started in May, and therefore there has not yet been much time to do anything, but the secretary will read to you a report of the business done so far as it has gone. I can assure you everything is as satisfactory as it can be. This time of year is not the best for bringing out subsidiary companies, and we have, therefore, deferred putting forward several that we have in hand until November.

The secretary then read the following report:—

The company was incorporated on the 1st May last, and the first allotment of shares was made on the 10th of the same month. The total number of shares that have been applied for is 28,147, of which number 27,937 have been allotted to 307 shareholders, leaving a balance of 2,063 to be taken up before a quotation on the Stock Exchange can be obtained. On the 16th June an agreement was entered into with Mr. William Crookes, F.R.S., by which the company undertook to purchase his incandescent lamp upon very favourable terms. The directors congratulate the shareholders upon having acquired this light, as an incandescent lamp is indispensable for household lighting, and they consider Mr. Crookes's lamp by far the most perfect invented, both as regards durability and economy. The directors have also the pleasure to announce that Mr. Crookes has accepted a seat on the board, and they feel assured that the company cannot but derive great benefit from the services and advice of such an experienced and well-known electrician. The directors beg to announce that they have disposed of a concession for the sale of Gülcher dynamos and lamps in Scotland, and that they are negotiating for the sale of further concessions for districts and towns. The Gülcher light was exhibited at the fêtes of the Royal Horticultural and Botanic Societies, and was very much admired both for its brilliancy, steadiness, and softness; and H.R.H. the Duchess of Teck, on the occasion of the *fête* at the Botanical Gardens, sent for Mr. Gülcher and congratulated him upon the success of his light. Messrs. Ransome, Josselyn, and Woods, of Battersea Foundry, who are manufacturing dynamos and lamps for the Gülcher Company, have, of course, had great difficulties to contend with at first, as, with the exception of Mr. Gülcher and his foreman, the work was comparatively new to all; but the directors are happy now to be in a position to announce that these difficulties have been successfully overcome, and that dynamos are being manufactured at Battersea which Mr. Gülcher pronounces to be perfect in every respect. Lamps of various candle-power are also being manufactured. A special factory has been constructed at Battersea for the manufacture of Crookes's incandescent lamps, where they are now being made, and in a short time it is expected that they will be turned out at the rate of over one thousand per week. The directors are happy to say that they have numerous orders in hand for installations from various parts of the country, and that the plant for the execution of these orders will be delivered during the course of the next month. They are also negotiating with subscribers to hire the light from two large centres; the net income from one of which alone will be from £5,000 to £6,000 per annum, and the second centre referred to is likely to be on quite as large a scale. The directors have decided to send exhibits to the North East Coast Exhibition, to be held at Tynemouth, commencing on the 6th September; to the Crystal Palace Electrical Exhibition, commencing in October next, and also to the Royal Aquarium Electrical Exhibition, to be held during the coming winter. The directors have the pleasure of stating that arrangements have been come to between the company and one of the most influential firms in New Zealand to represent them there as their agents; and they expect shortly to conclude a similar arrangement with another eminent firm for representation in India. Both these agencies are likely to result in the formation of large branch companies in these colonies. The directors think that they may congratulate the shareholders upon the prospects for the future of the company being most promising, and they look forward to the shares of the company rising considerably in value at no far distant date.

The Chairman said: Having heard this report, gentlemen, I have very few words to say in addition to it. I am not aware that it is usual to move the adoption of such a report, it is issued for the benefit and for the information of the shareholders. The directors are quite confident that the company is likely to prove a successful one, but, of course, it requires time. You have all read the report of Dr. Siemens at Southampton, in which he says electric light is undoubtedly the light of the future. As regards the arc light for factories and the incandescent light for mines, there is no doubt that the electric light is the light of the future. We have every advantage. We have made the best terms possible with Messrs. Ransome, who are very large manufacturers; and by making terms with them we have been able to save an expenditure of capital, which has not been the case in other companies. Of course you are aware that making dynamos, which are new,

requires considerable time. Even during the last two months, Messrs. Ransome have turned out several very valuable machines. I think the Brush Company were some considerable period before they turned out any good machines; and therefore so far, I think, we may congratulate ourselves on being very successful. As regards Mr. Crookes' lamp, it is the best yet produced, and we have purchased it on very favourable terms. Mr. Wm. Crookes, who is one of the first electricians in the country, has become a member of our board; and no doubt his addition to the board is a very great acquisition, as he at all times is ready at hand to give us his valuable advice. It will be, of course, to our interest to keep down expenses and to carry on the company in the best way that we can. With regard to concessions, there is no doubt we should have been more successful were it not owing to the state of affairs in the East. There has been a scare in the money market; but the fact that one gentleman has put down £1,000 on deposit for the Scotch concession is a proof of its *bona fides*. Another concession has fallen through, and I think it is a good job that it has, for the terms were not the most favourable to this company. We have still that part of the country to deal with. I think, gentlemen, I have no further information to give you now. I hope next time we meet I shall be able to report most successfully of the company. The information we now give is given voluntarily, for the sake of the shareholders.

Mr. Briers asked whether the board had yet given consideration to secondary batteries.

The Chairman said they had under consideration a new secondary battery, said to be very successful and cheap. It was at Messrs. Ransome's works, Battersea, and was being tested now. Of course these things required very great consideration. Enormous prices were asked for these different patents. Several patents had been offered them by one person and another; but the one they were now testing they were told was the best, so that they would then have the best arc lamp, the best incandescent lamp, and, they hoped, the best accumulator. Mr. Gülcher was present, and he had much pleasure in introducing him to the shareholders. That gentleman had done his best to meet their requirements; they had engaged his services for a time in order that he might be able to help them to realise their wishes. They were really very much indebted to Mr. Gülcher for the interest he had thrown into the concern.

Mr. R. J. Gülcher remarked that he was convinced that his system of electric lighting was a good one. As he had done his best in the past, so he promised to do in the future. He hoped the meeting would excuse him from saying more, as he was an indifferent public speaker.

The Chairman said if any other gentleman had any further question to ask in connection with the company, he should have pleasure in answering him.

After a pause, and no further question being asked,

Mr. Cornell said, as no question was asked, he should be happy to move a vote of thanks to the Chairman, and also to the directors.

Mr. Briers seconded, and the motion was carried unanimously.

MEDITERRANEAN EXTENSION TELEGRAPH COMPANY, LIMITED.

On Thursday morning, under the presidency of Sir James Carmichael (Chairman of the company), the fiftieth ordinary half-yearly general meeting of the shareholders of the above undertaking was held at Cannon Street Hotel.

The notice convening the meeting having been read by the secretary, Mr. Edward Tombs,

The Chairman said: Gentlemen, the report and accounts have been distributed and circulated amongst you several days, will you take them as read? ("Take them as read.") Well, gentlemen, in moving the adoption of the report and accounts which have been submitted to you, I would merely draw your attention to the fact that the result of our working has been so far satisfactory as to show a slight increase in the traffic for the past half-year, and this notwithstanding the interruption for upwards of two months of the Corfu-Otranto cable. With regard to that interruption I may say that the repairs to the cable were conducted in the most satisfactory manner. We were, unfortunately, unable to obtain any steamer in the Mediterranean with proper apparatus for doing that kind of work, so we chartered one of Messrs. Headley & Co. She called at Malta and took on board the spare cable, and then proceeded to Otranto to repair the damage. The vessel was a little delayed by bad weather, but when she did begin the repairs only occupied twelve hours, and we only used one and a half miles of new cable. There is another satisfactory matter in connection with these repairs—that is the admirable state in which we found the cable close to where this accident occurred. That cable was laid in 1859, twenty-three years ago. And it reflects great credit on Messrs. Glass, Elliott & Co. that that cable should have come up so well after lying down so many years. This is particularly encouraging to us, because the other cable, from Malta to Sicily, was laid ten years later on—in 1869—and, of course, even so much the better must the one now be than the other. That is an encouraging fact to bring under your notice. You will remember that this time last year negotiations were entered into with another company for the purchase of this company's business, but those negotiations then fell through. They have been renewed again, but I am not at the present time in a position to lay any definite offer before you. What I should propose would be, if anything should come out of them which we think it is desirable to adopt—for the board to recommend to you—to call a special meeting for the purpose; it might be later on in the autumn. With regard to the death of our lamented friend, Mr. Gurney, who has been connected with this company as director since its early formation, I am sure you will with myself and others feel much sympathy. I have now to propose the adoption of the report and accounts.

Mr. Attwell seconded the motion.

Mr. Crafter: Do we understand that before you conclude any definite arrangement with the new company to take over these lines you will call a meeting of our shareholders?

The Chairman: Most decidedly. We have no power to do that without consulting the shareholders.

Mr. J. Hengler (Liverpool): When does the Government subsidy expire?

The Chairman: In December next, at the end of the present year.

A Shareholder: Then really there will be no more dividends?

Mr. Crafter: You will go on working with the £12,000 reserve fund?

Another Shareholder: You have no dilapidated cables now?

The Chairman: No.

Mr. Vears thought the company could make hay while the sun shines. He came in to the meeting rather late, and, although he did not want to be troublesome, he should like to ask if the chairman would be so kind as to go out of his course and tell the meeting whether anything likely to be substantial would probably come out of the negotiations going on? Was there anything upon which the shareholders might base their hopes in this matter? The simple negation, "We cannot tell you anything" led one to ask, "What can you tell us? Tell us whatever of good you can."

The Chairman replied that of course Mr. Vears was aware that in business matters it was sometimes very injurious and damaging in stating anything until a definite arrangement had been arrived at. He did not think he could go any further than he had.

Mr. Crafter: The negotiations are still going on?

The Chairman: Yes, sir; they are not stopped.

A Shareholder: Suppose these negotiations fall through, what will be our position then?

The Chairman: You will have to depend upon the earnings of the company.

Mr. Vears remarked that he did not like the idea of no dividend at all. If they could not pay their present dividend he thought perhaps they might be able to pay 1½ on the company's earnings.

A Shareholder: What is the subvention from the Government?

The Chairman: The total subvention from the Government was £2,700 a year; the half of that sum has been the average we have received from them since the starting of the company. We have not had occasion to ask the Government for all of it. We have taken the whole of it, thus, on account of our repairs.

Mr. Crafter: Is this the last dividend we shall have?

The Chairman: The subvention does not expire till the end of the year.

A shareholder asked whether, as the £12,000 in hand was in Consols, and earning only 3 per cent., the board had power to invest that money in preference shares and so earn 8 per cent.?

The Chairman: We have no power to invest our £12,000 in preference shares.

Mr. Hedley said he should like to congratulate the shareholders on the satisfactory statement made by their chairman as to the duration of their cable. The one now repaired they were told had been down twenty-three years; and therefore he thought the old theory of the ten years' life of cables was exploded.

The Chairman: Yes; they are to be congratulated.

The Chairman then put the motion for the adoption of the report, which, having been seconded, was carried unanimously.

Mr. Beart then moved the re-election of the retiring directors—Sir James Carmichael, Bart., and the Hon. Ashley Ponsonby.

Mr. Vears seconded, and the motion was carried.

In reply to a question as to whether the board intended to fill the vacancy caused by Mr. Gurney's death,

The Chairman said they had not yet decided to do so; but when they did—perhaps at the next meeting—the nomination would be submitted to the shareholders.

A Shareholder thought three directors on the board was very few.

Mr. Crafter was of opinion that three could satisfactorily manage the concern.

A proposition for the re-election of Messrs. W. E. Allright and W. G. Hayward as auditors having been seconded, the motion was put and carried.

The Chairman: I have next to propose payment of the usual dividend at the rate of 8 per cent. per annum, less income-tax, on the company's preference stock, and at the rate of 3 per cent. per annum free of income-tax on its ordinary stock, payable on and after the 7th proximo. The proposition having been seconded, was carried unanimously; and, on the proposition of Mr. Field, a vote of thanks to the chairman concluded the business of the meeting.

SIR W. THOMSON'S RECORDERS FOR SUBMARINE CABLES.—We read in the *Operator* that the French Government is going to adopt Sir William Thomson's recorder as a means of correspondence on its cables between Marseilles and Algiers. These cables are at present worked by means of the mirror galvanometer. Six recording instruments are now in course of construction for the French Administration of Telegraphs at Mr. White's, of Glasgow, who is the only manufacturer of Sir William Thomson's recorders. It is expected that the instruments will be in full operation by the month of August next. A select party of operators are now undergoing a course of lectures and tuition in the use of the recorder in the rooms and under the supervision of Mr. Ternant, director of the Eastern Telegraph Company, at Marseilles. The latter company has employed the recording instrument from the commencement.